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Title of the Invention: MAGNETORESISTIVE ELEMENT

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[Document Name] SPECIFICATION

[TITLE OF THE INVENTION]

MAGNETORESISTIVE ELEMENT

[CLAIMS]

- 5 [Claim 1] A magnetoresistive element comprising:
 at least a first ferromagnet F1;
 a second ferromagnet F2; and
 a non-magnet N1 sandwiched between F1 and F2,
 wherein a resistance value depends on a relative angle formed by
 10 magnetization directions of F1 and F2 at interfaces of F1 and F2 with the
 non-magnet N1,
 wherein, assuming that R1 denotes an interface roughness of the
 interfaces of the ferromagnets F1 and F2 with N1, R1 after a heat treatment
 at 300°C or higher satisfies the following relation:
 15 $R1 \leq 20 \text{ nm}.$

- [Claim 2] A magnetoresistive element comprising:
 at least a first ferromagnet F1;
 a second ferromagnet F2; and
 20 a non-magnet N1 sandwiched between F1 and F2,
 wherein a resistance value depends on a relative angle formed by
 magnetization directions of F1 and F2 at interfaces of F1 and F2 with the
 non-magnet N1,
 wherein, assuming that: X denotes at least one element selected
 25 from Tc, Re, Ru, Os, Rh, Ir, Pd, Pt, Cu, Ag and Au; and x, y, z, a and b denote
 atomic compositions satisfying the relations of $x+y+z=100$, $a+b=100$,
 $40 \leq a \leq 99.7$ and $0.3 \leq b \leq 60$, at least a part of the ferromagnets F1 and F2 at an
 interface with the non-magnet N1 is formed of a ferromagnetic material of
 $(\text{Fe}_x\text{Co}_y\text{Ni}_z)_a\text{X}_b$ after a heat treatment at 300°C or higher.

- 30 [Claim 3] A magnetoresistive element comprising:
 at least a first ferromagnet F1;
 a second ferromagnet F2; and
 a non-magnet N1 sandwiched between F1 and F2,
 35 wherein a resistance value depends on a relative angle formed by
 magnetization directions of F1 and F2 at interfaces of F1 and F2 with the
 non-magnet N1,

wherein, assuming that: X denotes at least one element selected from Tc, Re, Ru, Os, Rh, Ir, Pd, Pt, Cu, Ag and Au; Y denotes at least one element selected from Mn and Cr; and x, y, z, a, b and c denote atomic compositions satisfying the relations of $x+y+z=100$, $a+b+c=100$, $40 \leq a \leq 99.7$, $0.3 \leq b+c \leq 60$, $0.3 \leq b \leq 60$ and $0 \leq c \leq 20$, at least a part of the ferromagnets F1 and F2 at an interface with the non-magnet N1 is formed of a ferromagnetic material of $(\text{Fe}_x\text{Co}_y\text{Ni}_z)_a\text{X}_b\text{Y}_c$ after a heat treatment at 300°C or higher.

[Claim 4] A magnetoresistive element comprising:

at least a first ferromagnet F1;

a second ferromagnet F2; and

a non-magnet N1 sandwiched between F1 and F2,

wherein a resistance value depends on a relative angle formed by magnetization directions of F1 and F2 at interfaces of F1 and F2 with the non-magnet N1,

wherein, assuming that: X denotes at least one element selected from Tc, Re, Ru, Os, Rh, Ir, Pd, Pt, Cu, Ag and Au; Y denotes at least one element selected from Mn and Cr; Z denotes at least one element selected from Ti, Zr, Hf, V, Nb, Ta, Mo, W, Al, Si, Ga, Ge, In and Sn; A denotes at least one element selected from B, C, N, O, P and S; and x, y, z, a, b, c, d and e denote atomic compositions satisfying the relations of $x+y+z=100$, $a+b+c+d+e=100$, $40 \leq a \leq 99.7$, $0.3 \leq b+c+d+e \leq 60$, $0.3 \leq b \leq 60$, $0 \leq c \leq 20$, $0 \leq d \leq 30$ and $0 \leq e \leq 20$, at least a part of the ferromagnets F1 and F2 at an interface with the non-magnet N1 is formed of a ferromagnetic material of $(\text{Fe}_x\text{Co}_y\text{Ni}_z)_a\text{X}_b\text{Y}_c\text{Z}_d\text{A}_e$ after a heat treatment at 300°C or higher.

[Claim 5] A magnetoresistive element according to any one of claims 2 to 4, wherein the metal alloy forming at least a part of the ferromagnets F1 and F2 at an interface with N1 is a metal alloy which is in a single phase state at a heat treatment temperature during a heat treatment process at 300°C or higher.

[Claim 6] A magnetoresistive element according to any one of claims 1 to 5, wherein at least a part of the ferromagnets F1 and F2 is in contact with an antiferromagnet directly or via a non-magnet and a third ferromagnet, and a distance between an interface where the antiferromagnet is in contact with at least a part of the ferromagnets F1 and F2 and an interface where at

least the ferromagnets F1 and F2 are in contact with N1 is between 3 nm and 50 nm inclusive.

[DETAILED DESCRIPTION OF THE INVENTION]

5 [0001]

[Field of the Invention]

The present invention relates to a magnetoresistive element used in a magnetic head for magnetic recording such as a hard disk drive (HDD) and a magnetic random access memory (MRAM).

10 [0002]

[Description of the Prior Art]

A multi-layer film with a basic structure of ferromagnet/non-magnet/ferromagnet can provide a magnetoresistance effect when current flows across the non-magnet. A spin tunnel effect can be obtained when using a tunnel insulating layer as the non-magnet, and a CPP (current perpendicular to the plane) GMR effect can be obtained when using a conductive metal layer of Cu or the like as the non-magnet. Both magnetoresistance effects (MR effects) depend on the magnitude of a relative angle between magnetizations of the ferromagnets that sandwich the non-magnet. The spin tunnel effect is derived from a change in transition probability of tunnel electrons flowing between the two magnets with the relative angle of magnetizations. The CPP-GMR effect is derived from a change in spin-dependent scattering.

[0003]

25 This ferromagnetic tunnel contact and the CPP-GMR are used as magnetoresistive elements, a part of plural ferromagnets is used as a memory layer, a memory is written by changing a magnetic direction of the ferromagnet as the memory layer, and memory is read out by detecting a resistance change resulted therefrom.

30 [0004]

Specifically, a magnetic material is made to be in a state where a magnetic direction hardly changes with respect to external magnetic field, by using a rigid magnetic material with a high coercivity, or by having a layered structure including a ferromagnet and an antiferromagnet, which is so-called "pinned". Whereas, a soft magnetic material that changes a magnetic direction in lower magnetic fields than the above-mentioned magnetic material is used, and change only the magnetic direction of the

soft magnet by any of methods (usually, by disposing a conductor in the vicinity thereof, letting a current flow in the conductor, and generating a magnetic field) so as to write the memory.

[0005]

- 5 When a magnetoresistive element is used in a device, particularly in a magnetic memory such as MRAM, a monolithic structure combining the magnetoresistive element and a conventional Si semiconductor is necessary in view of the cost and the degree of integration.

[0006]

- 10 [Problems to be solved by the invention]

To remove defects in wiring, a Si semiconductor includes heat treatment at high temperatures. This heat treatment is performed, e.g., in hydrogen at about 400°C to 450°C. However, the MR characteristics of the magnetoresistive element are degraded under heat treatment at 300°C to 350°C or more (see The 8th Joint MMM-Intermag Conference; AD-13 Freitas et. al., Review of Japan Magnetics Society of Japan, vol. 25, No. 4-2, P. 779 (2001) Amano et. al, Material for 16th workshop of Japan Magnetics Society of Japan, P. 16, and the like).

[0007]

- 20 A method for incorporating the magnetoresistive element after formation of the semiconductor element also has been proposed (see Material for 112th workshop of Japan Magnetics Society of Japan, P. 41). However, this method requires that wiring or the like for applying a magnetic field to the magnetoresistive element, the magnetoresistive element-the semiconductor element and the magnetoresistive element should be formed after producing the magnetoresistive element. Therefore, heat treatment is needed eventually, or a variation in wiring resistance is caused, degrading the reliability and stability of the element.

[0008]

- 30 In the light of the above-mentioned conventional problem, it is the object of the present invention to provide a magnetoresistive element that shows excellent MR characteristics after a heat treatment at 300°C or higher, in particular, 350°C or higher.

[0009]

- 35 [Means for solving problems]

In order to attain the above-mentioned object, a magnetoresistive element includes: at least a first ferromagnet F1; a second ferromagnet F2;

and a non-magnet sandwiched between F1 and F2, wherein a resistance value depends on a relative angle formed by magnetization directions of F1 and F2 at interfaces of F1 and F2 with the non-magnet, wherein, assuming that R1 denotes an interface roughness of the interfaces of the ferromagnets F1 and F2 with N1, R1 after a heat treatment at 300°C or higher satisfies the following relation: $R1 \leq 20$ nm. Moreover, a particularly preferable effect can be obtained, when the relation of $R1 \leq 10$ nm is satisfied after the heat treatment at 350°C or higher.

[0010]

In order to attain the above-mentioned object, in another structure of the present invention, a magnetoresistive element includes: at least a first ferromagnet F1; a second ferromagnet F2; and a non-magnet N1 sandwiched between F1 and F2, wherein a resistance value depends on a relative angle formed by magnetization directions of F1 and F2 at interfaces of F1 and F2 with the non-magnet N1, wherein, assuming that: X denotes at least one element selected from Tc, Re, Ru, Os, Rh, Ir, Pd, Pt, Cu, Ag and Au; and x, y, z, a and b denote atomic compositions satisfying the relations of $x+y+z=100$, $a+b=100$, $40 \leq a \leq 99.7$ and $0.3 \leq b \leq 60$, at least a part of the ferromagnets F1 and F2 at an interface with the non-magnet N1 is formed of a ferromagnetic material of $(Fe_xCo_yNi_z)_aX_b$ after a heat treatment at 300°C or higher.

[0011]

Also in this case, a particularly preferable effect can be obtained, when the heat treatment is conducted at 350°C or higher.

[0012]

In order to attain the above-mentioned object, in still another structure of the present invention, a magnetoresistive element includes: at least a first ferromagnet F1; a second ferromagnet F2; and a non-magnet N1 sandwiched between F1 and F2, wherein a resistance value depends on a relative angle formed by magnetization directions of F1 and F2 at interfaces of F1 and F2 with the non-magnet N1, wherein, assuming that: X denotes at least one element selected from Tc, Re, Ru, Os, Rh, Ir, Pd, Pt, Cu, Ag and Au; Y denotes at least one element selected from Mn and Cr; and x, y, z, a, b and c denote atomic compositions satisfying the relations of $x+y+z=100$, $a+b+c=100$, $40 \leq a \leq 99.7$, $0.3 \leq b+c \leq 60$, $0.3 \leq b \leq 60$ and $0 \leq c \leq 20$, at least a part of the ferromagnets F1 and F2 at an interface with the non-magnet N1 is formed of a ferromagnetic material of $(Fe_xCo_yNi_z)_aX_bY_c$ after a heat

treatment at 300°C or higher.

[0013]

Also in this case, a particularly preferable effect can be obtained, when the heat treatment is conducted at 350°C or higher.

- 5 [0014] In order to attain the above-mentioned object, in still another structure of the present invention, a magnetoresistive element includes: at least a first ferromagnet F1; a second ferromagnet F2; and a non-magnet N1 sandwiched between F1 and F2, wherein a resistance value depends on a relative angle formed by magnetization directions of F1 and F2 at interfaces of F1 and F2 with the non-magnet N1, wherein, assuming that: X denotes at least one element selected from Tc, Re, Ru, Os, Rh, Ir, Pd, Pt, Cu, Ag and Au; Y denotes at least one element selected from Mn and Cr; Z denotes at least one element selected from Ti, Zr, Hf, V, Nb, Ta, Mo, W, Al, Si, Ga, Ge, In and Sn; A denotes at least one element selected from B, C, N, O, P and S; and x, y, z, a, b, c, d and e denote atomic compositions satisfying the relations of $x+y+z=100$, $a+b+c+d+e=100$, $40 \leq a \leq 99.7$, $0.3 \leq b+c+d+e \leq 60$, $0.3 \leq b \leq 60$, $0 \leq c \leq 20$, $0 \leq d \leq 30$ and $0 \leq e \leq 20$, at least a part of the ferromagnets F1 and F2 at an interface with the non-magnet N1 is formed of a ferromagnetic material of $(\text{Fe}_x\text{Co}_y\text{Ni}_z)_a\text{X}_b\text{Y}_c\text{Z}_d\text{A}_e$ after a heat treatment at 300°C or higher.

20 [0015]

Also in this case, a particularly preferable effect can be obtained, when the heat treatment is conducted at 350°C or higher.

[0016]

- 25 In the above-mentioned structure of the present invention, a particularly preferable effect can be obtained, when the metal alloy forming at least a part of the ferromagnets F1 and F2 at an interface with N1 is a metal alloy which is in a single phase state at a heat treatment temperature during a heat treatment process.

[0017]

- 30 A magnetoresistive element according to any one of claims 1 to 5, wherein at least a part of the ferromagnets F1 and F2 is in contact with an antiferromagnet directly or via a non-magnet and a third ferromagnet, and a distance between an interface where the antiferromagnet is in contact with at least a part of the ferromagnets F1 and F2 and an interface where at least the ferromagnets F1 and F2 are in contact with N1 is between 3 nm and 50 nm inclusive.

[0018]

Embodiments of the present invention will be described as follows.

As the substrate, a substance with an insulated surface, e.g., a Si substrate obtained by thermal oxidation, a quartz substrate, and a sapphire substrate can be used. Since the substrate surface should be smoother, a smoothing
 5 process, e.g., chemomechanical polishing (CMP) may be performed as needed. A switching element such as a MOS transistor may be produced on the substrate surface beforehand. In this case, an insulating layer is formed on the switching element, and then contact holes are provided at only a part in need.

10 [Mode for carrying out the invention]
 [0019]

As a method for forming each layer of the multi-layer film, a general thin film producing method may be employed, e.g., sputtering, molecular
 15 beam epitaxy (MBE), chemical vapor deposition (CVD), pulse laser deposition, and ion beam sputtering. As a micro-processing method, well-known micro-processing methods, such as photolithography using a contact mask or stepper, EB lithography and focused ion beam (FIB) processing, may be employed.

[0020]

20 For etching, well-known etching methods, such as ion milling, reactive ion etching (RIE), ion milling and RIE using ICP plasma may be employed.

[0021]

25 For smoothing and removing unnecessary parts of formed film, a known CMP and a precision lapping may be employed.

[0022]

Heat treatment in vacuum, inert gas or hydrogen gas for improving element characteristics was performed either in non-magnetic field or magnetic field. In particular, in the case of the elements having a structure
 30 that needs a heat treatment in magnetic field, a heat treatment at 260°C to 300°C in magnetic field with 1 kOe to 30 kOe is conducted, then a heat treatment was conducted again. In this case, excellent magnetic characteristics can be obtained even by a heat treatment in non-magnetic field, but a stable and excellent magnetic characteristics curve can be
 35 obtained when a heat treatment is conducted in a magnetic field in the same direction as that of the initial pin heat treatment, or when a heat treatment is conducted again in a magnetic field in the same direction after the heat

treatment in non-magnetic field.

[0023]

Even with a conventional magnetoresistive element, the MR characteristics after heat treatment sometimes is constant or improved if the temperature is up to about 300°C. However, the MR characteristics are degraded after heat treatment at 300°C or more, alternatively, the MR characteristics sustains when the temperature is up to 350°C, and then are degraded after heat treatment at 350°C or more. Therefore, an effect according to the structure of the present invention is superior to that of the conventional example at heat treatment temperature of 300°C or more, being more conspicuous at 350°C or more. Considering that the element is combined with a Si semiconductor process, the heat treatment temperature should be about 400°C. The present invention can provide an element that exhibits practical characteristics even for heat treatment at 400°C. In addition, a heat treatment at 400°C or more, which is for suppressing wiring defects or reducing contact resistance between wirings or between a wiring and an element, and a heat treatment at 300°C or more for improving characteristics of magnetoresistive elements of the present invention may be conducted at the same time, which is an effective means in the light of reducing cost.

[0024]

For evaluating roughness of an interface of the non-magnet of the present invention, measurement may be performed based on a cross-sectional image obtained with a transmission electron microscope (TEM). Simple evaluation also can be performed in the following manner: a model film is prepared by stopping the film forming process after the non-magnet N1 is deposited; the model film is subjected to in-situ heat treatment in vacuum; and the surface shape is observed with an atomic force microscope while maintaining the state of the film.

[0025]

For obtaining roughness R1, maximum deviation (a maximum value of deviation from the average line of the curve in the range) at the interface with a length of 50 nm is measured at ten portions. And eight values excluding the maximum and the minimum values are taken to calculate an average, which is the sample R1. Furthermore, particularly when the relation of $R1 \leq 5$ nm was satisfied, the MR properties including the magnetoresistive curve were excellent.

[0026]

Among the types of "roughness" of the interface, the roughness exerts a different effect on the MR characteristics depending on whether it occurs in a short period or long period. Therefore, if R1 is defined with relatively wider range, waviness on the interfaces may occur in R1, thus roughness without relation with the characteristics occurs in R1. Taking the effect into consideration, the minimum radius of curvature of the waviness within a certain range is preferable as the definition of the roughness. Thus, when the minimum radius of curvature is measured at ten portions in the range of 50 to 100 nm, and the average of eight values among them is defined as the minimum radius of curvature of the sample, a sample with the minimum radius of curvature of 2 nm or more has excellent characteristics after the heat treatment. In particular, a sample with the minimum radius of curvature of 30 nm or more has excellent MR characteristics including a magnetoresistive curve after the heat treatment. However, at present, there is a limit to controlling the thickness of a sample for TEM observation. Therefore, at a portion having a sufficiently small thickness, the radius of curvature can be determined. However, at the other portion, since the interfaces tend to be overlapped in the thickness direction, it is impossible to clearly specify the minimum radius of curvature of a sample having a particularly small minimum radius of curvature. When the minimum radius of curvature may be determined, and it is larger than 2nm or larger than 30 nm, the MR characteristics are excellent, or the MR characteristics including the magnetoresistive curve are excellent. Each of these samples is basically 20 nm or less, or 5 nm in R1 of the present invention. Depending on the progress in technique of producing samples for TEM observation, ranges determined by the above two definitions which provide excellent MR characteristics after the heat treatment have conformity with each other, alternatively, the range determined by the minimum radius of curvature determines the range that provides a preferable characteristics more precisely.

[0027]

An element having small R1 after the heat treatment may be obtained if the composition thereof is within the range limited in the present invention, and the element is formed after surfaces of electrodes which are on a single-crystal substrate is subjected to the heat treatment at 400°C or higher so as to reduce distortion, and suppressing the surface roughness by

ion-milling the surface at a low angle or irradiating it with a gas cluster ion beam. In this case, the magnetic characteristics are excellent. When not using the single-crystal substrate, a sample, which is obtained by forming a film on the electrodes and lower magnet, performing the heat treatment at 400°C or more, suppressing the surface roughness, forming a non-magnet or another lower magnet thereon, and then forming a non-magnet, may provide small R1 after the heat treatment with a low possibility, though. In this case, the MR characteristics after the heat treatment were excellent. The sample in which a composition near the interface with the non-magnet after the heat treatment is in the range of the present invention provides small R1 after the heat treatment with pretty high possibility, thus obtaining the excellent MR characteristics.

[0028]

In the sample with small R1 after the heat treatment, the MR characteristics not only maintained, but also tended to improve further in the heat treatment at 300°C or more. The reason for an improvement in MR characteristics by heat treatment is not clarified fully. However, the heat treatment may improve the barrier characteristics of the non-magnet. This is because favorable MR characteristics can be obtained generally by reducing defects in a barrier or increasing the height of the barrier. Conventionally, the effect of improving the MR characteristics reaches a constant value in heat treatment at 300°C, but with the range of R1 of the present invention, there is a possibility of generating defect reduction at 300°C or more in a reaction or mechanism that is different from that at 300°C or less. Another possible reason is a change in chemical bond at the interfaces between the non-magnet and the ferromagnets. At present, the mechanism thereof is not known, but the possibility that the MR characteristics of the magnetoresistive element is easily affected by the state of the bond at the interfaces between the non-magnet and the ferromagnets.

[0029]

To analyze the composition, a local composition analysis using, e.g., TEM may be preformed. A model film obtained by stopping the film forming process after the non-magnet is deposited may be used as the ferromagnet located below the non-magnet. In this case, the model film is heat-treated at a predetermined temperature, then the non-magnet is removed appropriately by milling, and thus the composition is measured

with surface analysis such as Auger electron spectroscopy and XPS composition analysis.

[0030]

When the composition at the interfaces between the non-magnet and the ferromagnets is in the range of the present invention, a small R1 and improvement of MR characteristics at 300°C or more can be achieved easily with high possibilities. The reason for it is thought that the bond of non-magnets forming a barrier is reinforced easily because noble metal such as Tc, Re, Ru, Os, Rh, Ir, Pd, Pt, Cu, Ag, Au or the like have a catalytic effect on oxygen or the like. When adding more than 60 at%, the MR characteristics deteriorate. Another reason for it is thought to be deterioration of the characteristics as ferromagnets due to increase of an amount of the non-magnetic additive element.

[0031]

For the balance of the effect, the particularly preferred content of the element such as Tc, Re, Ru, Os, Rh, Ir, Pd, Pt, Cu, Ag, Au or the like is 3% or more, and 30% or less.

[0032]

It is known that a Mn-based antiferromagnet such as PtMn and a Cr-based antiferromagnet which are used as fixed beds degrade the characteristics, because the elements such as Mn, which are oxidized easily and form oxides having magnetism, diffuse in the vicinity of the barrier interfaces.

[0033]

However, in the present invention, if Mn, Cr or the like is added together with Tc, Re, Ru, Os, Rh, Ir, Pd, Pt, Cu, Ag, Au, when the content of Mn, Cr or the like is about 20% or less, the significant deterioration of the MR characteristics does not occur unlike in the conventional example. In particular, when the content of Mn, Cr or the like is less than that of Tc, Re, Ru, Os, Rh, Ir, Pd, Pt, Cu, Ag, Au or the like, the deterioration does not occur, and some samples rather show improvement of the MR characteristics after the heat treatment. There are some cases where the MR characteristics after the heat treatment are improved rather than degraded, comparing with the case of adding no Mn or Cr. It is not certain that the improvement of the MR characteristics is due to the effect of adding Mn and Cr, considering a range of variation of the characteristics, but the results were obtained showing that the add of Mn, Cr or the like together with Tc, Re, Ru,

Os, Rh, Ir, Pd, Pt, Cu, Ag, Au or the like may contribute to the further improvement of the MR characteristics after the heat treatment.

[0034]

When the magnetoresistive element is used in a device, the magnetic characteristics as an usual magnet, such as soft magnetic properties and high-frequency properties, become more important than the MR characteristics. Therefore, by adding an element such as Ti, Zr, Hf, V, Nb, Ta, Mo, W, Al, Si, Ga, Ge, In, Sn or the like, or an element such as B, C, N, O, P, S or the like, together with Tc, Re, Ru, Os, Rh, Ir, Pd, Pt, Cu, Ag, Au or the like, or further with Mn, Cr or the like, it becomes possible to manufacture a magnetoresistive element with the MR characteristics and the usual magnetic characteristics which are controlled so as to be balanced.

[0035]

After analyzing the composition at the interfaces by the above-mentioned composition analysis, an alloy having the same composition as that at the interfaces was molded by general molding, which then was heat-treated in inert gas at 350°C to 450°C for 24 hours. This alloy was cut substantially in half, and then the cutting planes were polished and etched. The state of particles on the surface was observed with a metallurgical microscope and an electron microscope. Moreover, the composition distribution was evaluated by the above composition analysis or EDX. The result confirmed that when a composition showed an uniform phase at heat treatment temperatures used, there was high stability in MR characteristics after heat treatment for a long time. When a composition showed a nonuniform phase at heat treatment temperatures used, there was a high probability of degradation in MR characteristics after heat treatment for a long time. A bulk material differs from a thin film in phase stability depending on the effect of the interfaces. In the sample with the composition showing a nonuniform phase, plural phases may be deposited to the interfaces due to the heat treatment, and the composition in some part may be beyond the composition range of the present invention, alternatively, a deterioration caused by the interfaces between the phases may occur.

[0036]

In the case of adding the element such as Mn, Cr or the like together with the element such as Tc, Re, Ru, Os, Rh, Ir, Pd, Pt, Cu, Ag, Au or the like so as to obtain a preferable MR characteristics after the heat treatment, an antiferromagnet such as PtMn, PdPtMn, IrMn, FeMn, NiMn, RhMn,

CrMnPt, CrAl, CrRu and the like may be used as a fixed bed, and the diffusion from the antiferromagnet caused by the heat treatment may be utilized. In this case, for controlling the content of Mn or Cr to be in the range of the present invention, excellent MR characteristics can be obtained if time of the heat treatment is adjusted at temperature ranging approximately between 300°C and 450°C, with a distance between the interface of the antiferromagnet and the interface of the non-magnetic barrier ranging between 3 nm and 50 nm.

[0037]

The above-mentioned methods are some of the examples, and the present invention is not limited by the above-mentioned examples.

[0038]

(A first embodiment)

A Pt film having a thickness of 1000 Å was evaporated on a single-crystal MgO (100) substrate as a lower electrode with MBE, which then was heat-treated in vacuum at 400°C for 3 hours. The substrate was irradiated with Ar ions at an incidence angle of 10° to 15° by using an ion gun, thus cleaning the surface and decreasing the roughness on the surface.

Next, a NiFe film having a thickness of 8 nm was formed on the Pt film with RF magnetron sputtering. Further, an Al film formed by DC magnetron sputtering was oxidized by introducing pure oxygen into a vacuum chamber so as to produce an AlO_x barrier. Subsequently, a Fe₅₀Co₅₀ film having a thickness of 10 nm was formed as magnetoresistive elements. With patterning by photolithography and ion milling etching, a plurality of magnetoresistive elements for evaluation having the same configuration as that shown in FIG. 1 were produced. A Cu film was formed as an upper electrode with DC magnetron sputtering, and a SiO₂ film was formed as an interlayer insulating film with ion beam sputtering.

The MR ratio of each of the magnetoresistive elements was measured by measuring a resistance with a DC four-terminal method while applying a magnetic field. The MR characteristics was measured after each of the heat treatments at 260°C for 1 hour, at 300°C for 1 hour, at 350°C for 1 hour, and at 400°C for 1 hour. After measurement of the MR ratio, R₁ was measured for each element. Table 1 shows the results.

[0039]

[Table 1]

TABLE 1A

No heat treatment	R1	$R1 \leq 3$	$3 < R1 \leq 10$	$10 < R1 \leq 20$	$20 < R1$
	MR(%) (average/max)	12/13.5	11.9/13.2	10.5/12.8	8.2/-
	Number of corresponding samples	80	12	6	1
260°C	R1	$R1 \leq 3$	$3 < R1 \leq 10$	$10 < R1 \leq 20$	$20 < R1$
	MR(%) (average/max)	14.1/15.2	13.8/14.8	12.5/13.2	8.5/9.2
	Number of corresponding samples	82	12	3	3
300°C	R1	$R1 \leq 3$	$3 < R1 \leq 10$	$10 < R1 \leq 20$	$20 < R1$
	MR(%) (average/max)	15.8/16.0	15.5/15.9	14.5/14.9	2.1/9.2
	Number of corresponding samples	62	15	9	12
350°C	R1	$R1 \leq 3$	$3 < R1 \leq 10$	$10 < R1 \leq 20$	$20 < R1$
	MR(%) (average/max)	16.2/16.4	15.7/16.0	14.5/14.9	1.9/5.2
	Number of corresponding samples	17	14	26	33
400°C	R1	$R1 \leq 3$	$3 < R1 \leq 10$	$10 < R1 \leq 20$	$20 < R1$
	MR(%) (average/max)	16.4/16.6	15.9/16.1	14.5/14.9	1.8/2.3
	Number of corresponding samples	3	6	15	51

The total number of samples varies depending on a heat treatment temperature.

[0040]

In addition, FIG. 2 is for describing the definition of R1 of the present invention, which is a radius of curvature.

[0041]

5 Magnetoresistive elements were produced in the same manner except that a Si substrate obtained thermal oxidation was used as a substrate, a Cu film having a thickness of 1000 Å and a Ta film having a thickness of 50 Å were used as a lower electrode. Both Cu and Ta films were formed by RF magnetron sputtering, the NiFe film was formed by DC
10 magnetron sputtering, the Co₇₅Fe₂₅ film was formed by RF magnetron sputtering, the BN film was formed by reactive evaporation, and the Fe₅₀Co₅₀ film was formed by RF magnetron sputtering.

The MR ratio and R1 were measured for each magnetoresistive element in the same manner as the above. Table 2 shows the results.

[0042]

[Table 2]

TABLE 2

No heat treatment	R1	$R1 \leq 3$	$3 < R1 \leq 10$	$10 < R1 \leq 20$	$20 < R1$
	MR(%) (average/max)	18.1/20.0	17.9/19.5	15.5/17.8	10.2/13.2
	Number of corresponding samples	67	22	7	4
260°C	R1	$R1 \leq 3$	$3 < R1 \leq 10$	$10 < R1 \leq 20$	$20 < R1$
	MR(%) (average/max)	18.2/20.1	18.0/19.7	16.5/17.9	12.1/13.5
	Number of corresponding samples	69	21	5	5
300°C	R1	$R1 \leq 3$	$3 < R1 \leq 10$	$10 < R1 \leq 20$	$20 < R1$
	MR(%) (average/max)	19.5/20.3	19.1/19.9	17.5/18.8	11.8/13.5
	Number of corresponding samples	36	36	9	15
350°C	R1	$R1 \leq 3$	$3 < R1 \leq 10$	$10 < R1 \leq 20$	$20 < R1$
	MR(%) (average/max)	19.7/20.5	19.2/20.2	17.5/18.8	5.8/11.8
	Number of corresponding samples	15	16	21	36
400°C	R1	$R1 \leq 3$	$3 < R1 \leq 10$	$10 < R1 \leq 20$	$20 < R1$
	MR(%) (average/max)	19.9/20.6	19.2/20.0	16.8/18.5	2.8/5.6
	Number of corresponding samples	1	8	13	52

The total number of samples varies depending on a heat treatment temperature.

[0043]

5 Magnetoresistive elements were produced using a Si substrate obtained by thermal oxidation as a substrate, forming a Cu film having a thickness of 2000 Å and a TiN film having a thickness of 30 Å as a lower electrode, forming a NiFe film of 8 nm and a $\text{Co}_{75}\text{Fe}_{25}$ film of 2 nm by DC/RF magnetron sputtering, using an AlO_x film as non-magnet was oxidized by plasma oxidation, and forming a $\text{Fe}_{50}\text{Co}_{50}$ film of 5 nm thereon. The sample of magnetoresistive element was evaluated similarly, and the results are shown in Table 3.

[0044]

[Table 3]

TABLE 3

No heat treatment	R1	$R1 \leq 3$	$3 < R1 \leq 10$	$10 < R1 \leq 20$	$20 < R1$
	MR(%) (average/max)	22.1/24.2	21.5/24.1	20.1/22.8	15.5/17.9
	Number of corresponding samples	66	23	6	5
260°C	R1	$R1 \leq 3$	$3 < R1 \leq 10$	$10 < R1 \leq 20$	$20 < R1$
	MR(%) (average/max)	23.1/24.5	22.8/24.3	21.8/23.0	16.0/17.2
	Number of corresponding samples	67	20	6	7
300°C	R1	$R1 \leq 3$	$3 < R1 \leq 10$	$10 < R1 \leq 20$	$20 < R1$
	MR(%) (average/max)	24.1/24.7	23.5/24.3	22.0/22.8	12.5/15.1
	Number of corresponding samples	31	34	11	18
350°C	R1	$R1 \leq 3$	$3 < R1 \leq 10$	$10 < R1 \leq 20$	$20 < R1$
	MR(%) (average/max)	24.3/24.7	23.8/24.1	21.8/22.2	3.2/8.1
	Number of corresponding samples	3	7	14	58
400°C	R1	$R1 \leq 3$	$3 < R1 \leq 10$	$10 < R1 \leq 20$	$20 < R1$
	MR(%) (average/max)	-/-	23.8/23.9	21.6/21.6	2.6/3.6
	Number of corresponding samples	0	2	3	61

The total number of samples varies depending on a heat treatment temperature.

[0045]

As shown above, reducing R1 after the heat treatment leads to increase of the MR ratio. Basically the same results were obtained in both cases where $\text{Co}_{70}\text{Fe}_{30}$, $\text{Co}_{90}\text{Fe}_{10}$, $\text{Ni}_{60}\text{Fe}_{40}$, sendust, $\text{Fe}_{50}\text{Co}_{25}\text{Ni}_{25}$,

5 $\text{Co}_{70}\text{Fe}_{5}\text{Si}_{15}\text{B}_{10}$, or the like was used as the ferromagnets in the form of a single-layer or a multi-layer and where an Al_2O_3 film formed by reactive evaporation, an AlN film formed by plasma reaction, and a film of TaO, TaN or AlN formed by natural oxidation or nitridation was used as the non-magnet. Basically the same results also were obtained from the
10 magnetoresistive elements having the cross-sectional configurations as shown in FIG. 3. For the element that included a plurality of junctions (tunnel junctions) due to the non-magnet, the maximum R1 was used as R1 of the element. In these elements, CrMnPt (thickness: 20 to 30 nm), $\text{Tb}_{25}\text{Co}_{75}$ (10 to 20 nm), PtMn (20 to 30 nm), IrMn (10 to 30 nm), or PdPtMn
15 (15 to 30 nm) was used as the antiferromagnet, and Ru (thickness: 0.7 to 0.9 nm), Ir (0.3 to 0.5 nm), or Rh (0.4 to 0.9 nm) was used as the non-magnetic metal film.

[0046]

(A second embodiment)

20 Magnetoresistive elements were produced by the same methods of film forming and processing as those in Example 1. The composition of the film was analyzed by Auger electron spectroscopy, SIMS, and XPS. An Al_2O_3 film (thickness: 1.0 to 2 nm) was used as the non-magnet. The Al_2O_3 film was produced by forming an Al film by ICP magnetron sputtering and
25 oxidizing the Al film in a chamber filled with a mixed gas of pure oxygen and high purity Ar. A Ru film (0.7 to 0.9 nm) was used as the non-magnetic metal layer, and PdPtMn (15 to 30 nm) was used as the antiferromagnet. Each type of the element, temperature of the heat treatment, composition of the ferromagnet near the interface with the non-magnet, composition of the
30 ferromagnet in the middle, the composition of the ferromagnet near the other interface (at %) and the MR ratio are shown in Tables 4a to 8d.

[0047]

[Table 4]

TABLE 4a)-1

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
1	a)	rt.	22.2	$\text{Co}_{75}\text{Fe}_{25}$	$\text{Co}_{75}\text{Fe}_{25}$	$\text{Co}_{75}\text{Fe}_{25}$	$\text{Co}_{75}\text{Fe}_{25}$	$\text{Ni}_{50}\text{Fe}_{20}$	$\text{Ni}_{50}\text{Fe}_{20}$
		260	24.5						
		300	24.3						
		350	15.3						
		400	10.1						
2	a)	rt.	22.3	$(\text{Co}_{75}\text{Fe}_{25})_{99.8}\text{Pt}_{0.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.8}\text{Pt}_{0.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.8}\text{Pt}_{0.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.8}\text{Pt}_{0.2}$	$\text{Ni}_{50}\text{Fe}_{20}$	$\text{Ni}_{50}\text{Fe}_{20}$
		260	23.8						
		300	23.2						
		350	14.9						
		400	10.2						
3	a)	rt.	23.1	$(\text{Co}_{75}\text{Fe}_{25})_{99.7}\text{Pt}_{0.3}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.7}\text{Pt}_{0.3}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.7}\text{Pt}_{0.3}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.7}\text{Pt}_{0.3}$	$\text{Ni}_{50}\text{Fe}_{20}$	$\text{Ni}_{50}\text{Fe}_{20}$
		260	24.7						
		300	24.7						
		350	24						
		400	21.1						
4	a)	rt.	24.2	$(\text{Co}_{75}\text{Fe}_{25})_{97}\text{Pt}_3$	$(\text{Co}_{75}\text{Fe}_{25})_{97}\text{Pt}_3$	$(\text{Co}_{75}\text{Fe}_{25})_{97}\text{Pt}_3$	$(\text{Co}_{75}\text{Fe}_{25})_{97}\text{Pt}_3$	$\text{Ni}_{50}\text{Fe}_{20}$	$\text{Ni}_{50}\text{Fe}_{20}$
		260	25.2						
		300	25.4						
		350	26.3						
		400	25.4						

[0047] continued

[Table 4] continued

TABLE 4a)-2

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
5	a)	r.t.	23.8	$(\text{Co}_{75}\text{Fe}_{25})_{85}\text{Pt}_{15}$	$(\text{Co}_{75}\text{Fe}_{25})_{85}\text{Pt}_{15}$	$(\text{Co}_{75}\text{Fe}_{25})_{85}\text{Pt}_{15}$	$(\text{Co}_{75}\text{Fe}_{25})_{85}\text{Pt}_{15}$	$\text{Ni}_{80}\text{Fe}_{20}$	$\text{Ni}_{80}\text{Fe}_{20}$
		260	24.9						
		300	25.5						
		350	30.1						
		400	33.2						
6	a)	r.t.	23.9	$(\text{Co}_{75}\text{Fe}_{25})_{71}\text{Pt}_{29}$	$(\text{Co}_{75}\text{Fe}_{25})_{71}\text{Pt}_{29}$	$(\text{Co}_{75}\text{Fe}_{25})_{71}\text{Pt}_{29}$	$(\text{Co}_{75}\text{Fe}_{25})_{71}\text{Pt}_{29}$	$\text{Ni}_{80}\text{Fe}_{20}$	$\text{Ni}_{80}\text{Fe}_{20}$
		260	25.1						
		300	25.3						
		350	25						
		400	24.8						
7	a)	r.t.	18.9	$(\text{Co}_{75}\text{Fe}_{25})_{41}\text{Pt}_{59}$	$(\text{Co}_{75}\text{Fe}_{25})_{41}\text{Pt}_{59}$	$(\text{Co}_{75}\text{Fe}_{25})_{41}\text{Pt}_{59}$	$(\text{Co}_{75}\text{Fe}_{25})_{41}\text{Pt}_{59}$	$\text{Ni}_{80}\text{Fe}_{20}$	$\text{Ni}_{80}\text{Fe}_{20}$
		260	19.4						
		300	20.1						
		350	20.5						
		400	20.2						
8	a)	r.t.	12.5	$(\text{Co}_{75}\text{Fe}_{25})_{38}\text{Pt}_{62}$	$(\text{Co}_{75}\text{Fe}_{25})_{38}\text{Pt}_{62}$	$(\text{Co}_{75}\text{Fe}_{25})_{38}\text{Pt}_{62}$	$(\text{Co}_{75}\text{Fe}_{25})_{38}\text{Pt}_{62}$	$\text{Ni}_{80}\text{Fe}_{20}$	$\text{Ni}_{80}\text{Fe}_{20}$
		260	17.8						
		300	15.3						
		350	12.2						
		400	11.2						

[0048]

[Table 5]

TABLE 4b)-1

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
9	a)	rt.	19.1	Ni ₈₀ Fe ₂₀	Ni ₈₀ Fe ₂₀	Ni ₈₀ Fe ₂₀	Ni ₈₀ Fe ₂₀	Ni ₈₀ Fe ₂₀	Ni ₈₀ Fe ₂₀
		260	21.2						
		300	22.1						
		350	15.1						
		400	10.2						
10	a)	rt.	18.5	(Ni ₈₀ Fe ₂₀) _{98.5} Pt _{0.5} Pd _{0.7}	(Ni ₈₀ Fe ₂₀) _{98.5} Pt _{0.5} Pd _{0.7}	(Ni ₈₀ Fe ₂₀) _{98.5} Pt _{0.5} Pd _{0.7}	(Ni ₈₀ Fe ₂₀) _{98.5} Pt _{0.5} Pd _{0.7}	Ni ₈₀ Fe ₂₀	Ni ₈₀ Fe ₂₀
		260	19.9						
		300	18.1						
		350	15.8						
		400	11.2						
11	a)	rt.	19.1	(Ni ₈₀ Fe ₂₀) ₉₇ Pt _{0.2} Pd _{0.1}	(Ni ₈₀ Fe ₂₀) ₉₇ Pt _{0.2} Pd _{0.1}	(Ni ₈₀ Fe ₂₀) ₉₇ Pt _{0.2} Pd _{0.1}	(Ni ₈₀ Fe ₂₀) ₉₇ Pt _{0.2} Pd _{0.1}	Ni ₈₀ Fe ₂₀	Ni ₈₀ Fe ₂₀
		260	20.9						
		300	21.1						
		350	19.9						
		400	19.7						
12	a)	rt.	19.8	(Ni ₈₀ Fe ₂₀) ₉₇ Pt ₂ Pd ₁	(Ni ₈₀ Fe ₂₀) ₉₇ Pt ₂ Pd ₁	(Ni ₈₀ Fe ₂₀) ₉₇ Pt ₂ Pd ₁	(Ni ₈₀ Fe ₂₀) ₉₇ Pt ₂ Pd ₁	Ni ₈₀ Fe ₂₀	Ni ₈₀ Fe ₂₀
		260	22.1						
		300	22.3						
		350	22.2						
		400	22.1						

[0048] continued

[Table 5] continued

TABLE 4b)-2

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
13	a)	r.t.	18.8	$(\text{Ni}_{60}\text{Fe}_{40})_{85}\text{Pt}_{10}\text{Pd}_5$	$(\text{Ni}_{60}\text{Fe}_{40})_{85}\text{Pt}_{10}\text{Pd}_5$	$(\text{Ni}_{60}\text{Fe}_{40})_{85}\text{Pt}_{10}\text{Pd}_5$	$(\text{Ni}_{60}\text{Fe}_{40})_{85}\text{Pt}_{10}\text{Pd}_5$	$\text{Ni}_{80}\text{Fe}_{20}$	$\text{Ni}_{80}\text{Fe}_{20}$
		260	19.9						
		300	19.8						
		350	26.2						
		400	28.8						
14	a)	r.t.	18.7	$(\text{Ni}_{60}\text{Fe}_{40})_{71}\text{Pt}_{19}\text{Pd}_{10}$	$(\text{Ni}_{60}\text{Fe}_{40})_{71}\text{Pt}_{19}\text{Pd}_{10}$	$(\text{Ni}_{60}\text{Fe}_{40})_{71}\text{Pt}_{19}\text{Pd}_{10}$	$(\text{Ni}_{60}\text{Fe}_{40})_{71}\text{Pt}_{19}\text{Pd}_{10}$	$\text{Ni}_{80}\text{Fe}_{20}$	$\text{Ni}_{80}\text{Fe}_{20}$
		260	19.8						
		300	20.1						
		350	22.5						
		400	23.1						
15	a)	r.t.	18.7	$(\text{Ni}_{60}\text{Fe}_{40})_{41}\text{Pt}_{39}\text{Pd}_{20}$	$(\text{Ni}_{60}\text{Fe}_{40})_{41}\text{Pt}_{39}\text{Pd}_{20}$	$(\text{Ni}_{60}\text{Fe}_{40})_{41}\text{Pt}_{39}\text{Pd}_{20}$	$(\text{Ni}_{60}\text{Fe}_{40})_{41}\text{Pt}_{39}\text{Pd}_{20}$	$\text{Ni}_{80}\text{Fe}_{20}$	$\text{Ni}_{80}\text{Fe}_{20}$
		260	18.8						
		300	19.1						
		350	19.9						
		400	19.6						
16	a)	r.t.	16.4	$(\text{Ni}_{60}\text{Fe}_{40})_{38}\text{Pt}_{41}\text{Pd}_{21}$	$(\text{Ni}_{60}\text{Fe}_{40})_{38}\text{Pt}_{41}\text{Pd}_{21}$	$(\text{Ni}_{60}\text{Fe}_{40})_{38}\text{Pt}_{41}\text{Pd}_{21}$	$(\text{Ni}_{60}\text{Fe}_{40})_{38}\text{Pt}_{41}\text{Pd}_{21}$	$\text{Ni}_{80}\text{Fe}_{20}$	$\text{Ni}_{80}\text{Fe}_{20}$
		260	16.8						
		300	15.9						
		350	12.3						
		400	9.8						

[0049]

[Table 6]

TABLE 4c)-1

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3
17	a)	r.t.	22.5	Co ₉₀ Fe ₁₀	Co ₉₀ Fe ₁₀	Co ₇₅ Fe ₂₅
		260	24.5			
		300	24.1			
		350	15.2			
		400	9.9			
18	a)	r.t.	21.8	Co ₉₀ Fe ₁₀	Co ₉₀ Fe ₁₀	(Co ₇₅ Fe ₂₅) _{99.8} Ir _{0.1} Pd _{0.05} Rh _{0.05}
		260	23.7			
		300	23.4			
		350	15.3			
		400	11.3			
19	a)	r.t.	22.2	Co ₉₀ Fe ₁₀	Co ₉₀ Fe ₁₀	(Co ₇₅ Fe ₂₅) _{99.7} Ir _{0.15} Pd _{0.07} Rh _{0.08}
		260	24.2			
		300	24.1			
		350	23.9			
		400	23.8			
20	a)	r.t.	20.6	Co ₉₀ Fe ₁₀	Co ₉₀ Fe ₁₀	(Co ₇₅ Fe ₂₅) ₉₇ Ir _{1.5} Pd _{0.75} Rh _{0.75}
		260	22.9			
		300	23.3			
		350	24.2			
		400	24.5			

[0049] continued

[Table 6] continued

TABLE 4c)-2

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 4	Composition 5	Composition 6
17	a)	rt.	22.5	Co ₇₅ Fe ₂₅	Co ₇₅ Fe ₂₅	Co ₇₅ Fe ₂₅
		260	24.5			
		300	24.1			
		350	15.2			
		400	9.9			
18	a)	rt.	21.8	(Co ₇₅ Fe ₂₅) _{99.8} Ir _{0.1} Pd _{0.05} Rh _{0.05}	(Co ₇₅ Fe ₂₅) _{99.8} Ir _{0.1} Pd _{0.05} Rh _{0.05}	(Co ₇₅ Fe ₂₅) _{99.8} Ir _{0.1} Pd _{0.05} Rh _{0.05}
		260	23.7			
		300	23.4			
		350	15.3			
		400	11.3			
19	a)	rt.	22.2	(Co ₇₅ Fe ₂₅) _{99.7} Ir _{0.15} Pd _{0.07} Rh _{0.08}	(Co ₇₅ Fe ₂₅) _{99.7} Ir _{0.15} Pd _{0.07} Rh _{0.08}	(Co ₇₅ Fe ₂₅) _{99.7} Ir _{0.15} Pd _{0.07} Rh _{0.08}
		260	24.2			
		300	24.1			
		350	23.9			
		400	23.8			
20	a)	rt.	20.6	(Co ₇₅ Fe ₂₅) ₉₇ Ir _{1.5} Pd _{0.75} Rh _{0.75}	(Co ₇₅ Fe ₂₅) ₉₇ Ir _{1.5} Pd _{0.75} Rh _{0.75}	(Co ₇₅ Fe ₂₅) ₉₇ Ir _{1.5} Pd _{0.75} Rh _{0.75}
		260	22.9			
		300	23.3			
		350	24.2			
		400	24.5			

[0049] continued

[Table 6] continued

TABLE 4c)-3

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3
21	a)	r.t.	20.5	Co ₉₀ Fe ₁₀	Co ₉₀ Fe ₁₀	(Co ₇₅ Fe ₂₅) ₈₅ Ir _{7.5} Pd _{3.7} Rh _{3.8}
		260	21.4			
		300	22.6			
		350	26.8			
		400	27.3			
22	a)	r.t.	20.4	Co ₉₀ Fe ₁₀	Co ₉₀ Fe ₁₀	(Co ₇₅ Fe ₂₅) ₇₁ Ir _{14.5} Pd _{7.2} Rh _{7.3}
		260	21.1			
		300	22.2			
		350	25.2			
		400	25.5			
23	a)	r.t.	15.3	Co ₉₀ Fe ₁₀	Co ₉₀ Fe ₁₀	(Co ₇₅ Fe ₂₅) ₄₁ Ir _{29.5} Pd _{14.7} Rh _{14.8}
		260	20.2			
		300	21.4			
		350	23.2			
		400	23.1			
24	a)	r.t.	15.1	Co ₉₀ Fe ₁₀	Co ₉₀ Fe ₁₀	(Co ₇₅ Fe ₂₅) ₃₈ Ir ₃₁ Pd _{15.5} Rh _{15.5}
		260	20.1			
		300	19.7			
		350	15.1			
		400	10.2			

[0049] continued

[Table 6] continued

TABLE 4c)-4

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 4	Composition 5	Composition 6
21	a)	r.t.	20.5	$(\text{Co}_{75}\text{Fe}_{25})_{85}\text{Ir}_{7.5}\text{Pd}_{3.7}\text{Rh}_{3.8}$	$(\text{Co}_{75}\text{Fe}_{25})_{85}\text{Ir}_{7.5}\text{Pd}_{3.7}\text{Rh}_{3.8}$	$(\text{Co}_{75}\text{Fe}_{25})_{85}\text{Ir}_{7.5}\text{Pd}_{3.7}\text{Rh}_{3.8}$
		260	21.4			
		300	22.6			
		350	26.8			
		400	27.3			
22	a)	r.t.	20.4	$(\text{Co}_{75}\text{Fe}_{25})_{71}\text{Ir}_{14.5}\text{Pd}_{7.2}\text{Rh}_{7.3}$	$(\text{Co}_{75}\text{Fe}_{25})_{71}\text{Ir}_{14.5}\text{Pd}_{7.2}\text{Rh}_{7.3}$	$(\text{Co}_{75}\text{Fe}_{25})_{71}\text{Ir}_{14.5}\text{Pd}_{7.2}\text{Rh}_{7.3}$
		260	21.1			
		300	22.2			
		350	25.2			
		400	25.5			
23	a)	r.t.	15.3	$(\text{Co}_{75}\text{Fe}_{25})_{41}\text{Ir}_{29.5}\text{Pd}_{14.7}\text{Rh}_{14.8}$	$(\text{Co}_{75}\text{Fe}_{25})_{41}\text{Ir}_{29.5}\text{Pd}_{14.7}\text{Rh}_{14.8}$	$(\text{Co}_{75}\text{Fe}_{25})_{41}\text{Ir}_{29.5}\text{Pd}_{14.7}\text{Rh}_{14.8}$
		260	20.2			
		300	21.4			
		350	23.2			
		400	23.1			
24	a)	r.t.	15.1	$(\text{Co}_{75}\text{Fe}_{25})_{38}\text{Ir}_{31}\text{Pd}_{15.5}\text{Rh}_{15.5}$	$(\text{Co}_{75}\text{Fe}_{25})_{38}\text{Ir}_{31}\text{Pd}_{15.5}\text{Rh}_{15.5}$	$(\text{Co}_{75}\text{Fe}_{25})_{38}\text{Ir}_{31}\text{Pd}_{15.5}\text{Rh}_{15.5}$
		260	20.1			
		300	19.7			
		350	15.1			
		400	10.2			

[0050]

[Table 7]

TABLE 4d)-1

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
25	b)	r.t.	22.5	Ni ₈₀ Fe ₂₀	Ni ₈₀ Fe ₂₀	Co ₇₅ Fe ₂₅	Co ₇₅ Fe ₂₅	Co ₇₅ Fe ₂₅	Co ₇₅ Fe ₂₅
		260	34.2						
		300	36.1						
		350	22.2					(Co ₇₅ Fe ₂₅) _{99.1} Mn ₁	(Co ₇₅ Fe ₂₅) _{99.5} Mn ₅
		400	14.8					(Co ₇₅ Fe ₂₅) _{98.1} Mn ₂	(Co ₇₅ Fe ₂₅) _{99.0} Mn ₁₀
26	b)	r.t.	21.8	Ni ₈₀ Fe ₂₀	Ni ₈₀ Fe ₂₀	(Co ₇₅ Fe ₂₅) _{99.8} Pt _{0.2}	(Co ₇₅ Fe ₂₅) _{99.8} Pt _{0.2}	(Co ₇₅ Fe ₂₅) _{99.8} Pt _{0.2}	(Co ₇₅ Fe ₂₅) _{99.8} Pt _{0.2}
		260	33.8						
		300	35.5						
		350	18.9					(Co ₇₅ Fe ₂₅) _{99.8} Pt _{0.2} Mn ₁	(Co ₇₅ Fe ₂₅) _{99.8} Pt _{0.2} Mn ₅
		400	15.1					(Co ₇₅ Fe ₂₅) _{97.3} Pt _{0.7} Mn ₂	(Co ₇₅ Fe ₂₅) _{99.8} Pt _{0.2} Mn ₁₀
27	b)	r.t.	22.2	Ni ₈₀ Fe ₂₀	Ni ₈₀ Fe ₂₀	(Co ₇₅ Fe ₂₅) _{99.7} Pt _{0.3}	(Co ₇₅ Fe ₂₅) _{99.7} Pt _{0.3}	(Co ₇₅ Fe ₂₅) _{99.7} Pt _{0.3}	(Co ₇₅ Fe ₂₅) _{99.7} Pt _{0.3}
		260	34.1						
		300	35.7						
		350	35.5					(Co ₇₅ Fe ₂₅) _{99.8} Pt _{0.3} Mn _{0.9}	(Co ₇₅ Fe ₂₅) _{99.7} Pt _{0.3} Mn ₄
		400	32.2					(Co ₇₅ Fe ₂₅) _{97.9} Pt _{0.3} Mn _{1.8}	(Co ₇₅ Fe ₂₅) _{99.7} Pt _{0.3} Mn ₉
28	b)	r.t.	20.6	Ni ₈₀ Fe ₂₀	Ni ₈₀ Fe ₂₀	(Co ₇₅ Fe ₂₅) ₉₇ Pt ₃	(Co ₇₅ Fe ₂₅) ₉₇ Pt ₃	(Co ₇₅ Fe ₂₅) ₉₇ Pt ₃	(Co ₇₅ Fe ₂₅) ₉₇ Pt ₃
		260	33.3						
		300	34.4						
		350	35					(Co ₇₅ Fe ₂₅) _{99.2} Pt ₃ Mn _{0.8}	(Co ₇₅ Fe ₂₅) _{99.1} Pt _{2.9} Mn ₄
		400	34.9					(Co ₇₅ Fe ₂₅) _{99.4} Pt ₃ Mn _{1.6}	(Co ₇₅ Fe ₂₅) _{99.2} Pt _{2.8} Mn ₈

[0050] continued

[Table 7] continued

TABLE 4d-2

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
29	b)	r.t.	20.5	Ni ₈₀ Fe ₂₀	Ni ₈₀ Fe ₂₀	(Co ₇₅ Fe ₂₅) ₈₅ Pt ₁₅	(Co ₇₅ Fe ₂₅) ₈₅ Pt ₁₅	(Co ₇₅ Fe ₂₅) ₈₅ Pt ₁₅	(Co ₇₅ Fe ₂₅) ₈₅ Pt ₁₅
		260	33.5					(Co ₇₅ Fe ₂₅) _{84.6} Pt _{14.9} Mn _{0.5}	(Co ₇₅ Fe ₂₅) _{83.3} Pt _{14.7} Mn ₂
		300	35.1						
		350	36.5						
		400	41.1					(Co ₇₅ Fe ₂₅) _{84.2} Pt _{14.8} Mn ₁	(Co ₇₅ Fe ₂₅) _{81.6} Pt _{14.4} Mn ₄
30	b)	r.t.	20.4	Ni ₈₀ Fe ₂₀	Ni ₈₀ Fe ₂₀	(Co ₇₅ Fe ₂₅) ₇₁ Pt ₂₉	(Co ₇₅ Fe ₂₅) ₇₁ Pt ₂₉	(Co ₇₅ Fe ₂₅) ₇₁ Pt ₂₉	(Co ₇₅ Fe ₂₅) ₇₁ Pt ₂₉
		260	33.8					(Co ₇₅ Fe ₂₅) _{70.6} Pt _{28.9} Mn _{0.5}	(Co ₇₅ Fe ₂₅) _{69.6} Pt _{28.4} Mn ₂
		300	34.9						
		350	36.2						
		400	36.5					(Co ₇₅ Fe ₂₅) _{70.3} Pt _{28.7} Mn ₁	(Co ₇₅ Fe ₂₅) _{68.2} Pt _{27.8} Mn ₄
31	b)	r.t.	15.3	Ni ₈₀ Fe ₂₀	Ni ₈₀ Fe ₂₀	(Co ₇₅ Fe ₂₅) ₄₁ Pt ₅₉	(Co ₇₅ Fe ₂₅) ₄₁ Pt ₅₉	(Co ₇₅ Fe ₂₅) ₄₁ Pt ₅₉	(Co ₇₅ Fe ₂₅) ₄₁ Pt ₅₉
		260	29.5					(Co ₇₅ Fe ₂₅) _{40.8} Pt _{58.7} Mn _{0.5}	(Co ₇₅ Fe ₂₅) _{40.2} Pt _{57.8} Mn ₂
		300	31.1						
		350	33.2						
		400	30.2					(Co ₇₅ Fe ₂₅) _{40.6} Pt _{58.4} Mn ₁	(Co ₇₅ Fe ₂₅) _{39.4} Pt _{56.6} Mn ₄
32	b)	r.t.	12.4	Ni ₈₀ Fe ₂₀	Ni ₈₀ Fe ₂₀	(Co ₇₅ Fe ₂₅) ₃₈ Pt ₆₂	(Co ₇₅ Fe ₂₅) ₃₈ Pt ₆₂	(Co ₇₅ Fe ₂₅) ₃₈ Pt ₆₂	(Co ₇₅ Fe ₂₅) ₃₈ Pt ₆₂
		260	15.2					(Co ₇₅ Fe ₂₅) _{37.8} Pt _{61.7} Mn _{0.5}	(Co ₇₅ Fe ₂₅) _{37.2} Pt _{60.8} Mn ₂
		300	16.8						
		350	14.6						
		400	12.1					(Co ₇₅ Fe ₂₅) _{37.6} Pt _{61.4} Mn ₁	(Co ₇₅ Fe ₂₅) _{36.6} Pt _{59.5} Mn ₄

[0051]

The samples 1 to 8 in Table 4a) indicate that the addition of 0.3 to 60 at% Pt improves the MR characteristics after heat treatment at 300°C or more as compared with the sample that does not include Pt. In particular, the MR characteristics after heat treatment at 300°C or more tend to be improved by adding Pt in an amount of about 3 to 30 at%. The same tendency can be confirmed in each of the cases where $\text{Co}_{75}\text{Fe}_{25}$ in Table 4a) is replaced by $\text{Co}_{90}\text{Fe}_{10}$, $\text{Co}_{50}\text{Fe}_{50}$, $\text{Ni}_{60}\text{Fe}_{40}$ or $\text{Fe}_{50}\text{Co}_{25}\text{Ni}_{25}$, where $\text{Ni}_{80}\text{Fe}_{20}$ is replaced by sendust or $\text{Co}_{90}\text{Fe}_{10}$, and where Pt is replaced by Re, Ru, Os, Rh, Ir, Pd or Au.

[0052]

The samples 9 to 16 in Table 4b) indicate that the addition of Pt and Pd in a ratio of 2 : 1 in a total amount of 0.3 to 60 at%, particularly 3 to 30 at%, improves the MR characteristics after heat treatment at 300°C or more as compared with the sample that does not include Pt and Pd.

The same tendency can be obtained when the ratio of the elements added is changed from 2 : 1 to 10 : 1, 6 : 1, 3 : 1, 1 : 1, 1 : 2, 1 : 3, 1 : 6, or 1 : 10. Moreover, the same tendency can be obtained by replacing Pt of (Pt, Pd) with Tc, Re, Ru, Rh, Cu or Ag and replacing Pd with Os, Ir or Au, i.e., a total of 28 combinations of the elements including (Pt, Pd). Further, the same tendency can be obtained in both cases where $\text{Ni}_{60}\text{Fe}_{40}$ is replaced by $\text{Co}_{75}\text{Fe}_{25}$ or $\text{Fe}_{50}\text{Co}_{25}\text{Ni}_{25}$ and where $\text{Ni}_{80}\text{Fe}_{20}$ is replaced by sendust or $\text{Co}_{90}\text{Fe}_{10}$.

[0053]

The samples 17 to 24 in Table 4c) indicate that the addition of Ir, Pd and Rh in a ratio of 2 : 1 : 1 also improves the MR characteristics, like Tables 4a) and 4b). The same tendency can be confirmed when Ir is set to 1 and the contents of Pd and Rh are each changed in the range of 0.01 to 100. Moreover, the same tendency can be obtained in both cases where $\text{Co}_{90}\text{Fe}_{10}$ is replaced by $\text{Ni}_{80}\text{Fe}_{20}$, $\text{Ni}_{65}\text{Fe}_{25}\text{Co}_{10}$ or $\text{Co}_{60}\text{Fe}_{20}\text{Ni}_{20}$ and where $\text{Co}_{75}\text{Fe}_{25}$ is replaced by $\text{Co}_{50}\text{Fe}_{50}$, $\text{Fe}_{60}\text{Ni}_{40}$ or $\text{Fe}_{50}\text{Ni}_{50}$.

Further, the same tendency can be obtained by using the following combinations of the elements: (Tc, Re, Ag), (Ru, Os, Ir), (Rh, Ir, Pt), (Pd, Pt, Cu), (Cu, Ag, Au), (Re, Ru, Os), (Ru, Rh, Pd), (Ir, Pt, Cu), and (Re, Ir, Ag).

[0054]

The samples 25 to 32 in Table 4d) have the same tendency as that in Tables 4a) to 4c). Some samples show that Mn is diffused from the

antiferromagnet after heat treatment. However, the Mn diffusion can be suppressed by adding Pt. This indicates that the addition of Pt makes it possible to control the concentration of Mn at the interfaces of the non-magnet. The same tendency can be obtained by replacing Pt with Tc, Ru, Os, Rh, Ir, Pd, Cu or Ag. Moreover, the same tendency can be obtained by modifying the ferromagnets to the above compositions.

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[0055]

[Table 8]

TABLE 5a)-1

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
33	b)	r.t.	22.9	Co ₉₀ Fe ₁₀	Co ₉₀ Fe ₁₀	Co ₉₀ Fe ₁₀	Co ₇₅ Fe ₂₅	Co ₇₅ Fe ₂₅	Co ₇₅ Fe ₂₅
		260	34.1						
		300	34.3						
		350	23.5					(Co ₇₅ Fe ₂₅) ₉₉ Mn ₁	(Co ₇₅ Fe ₂₅) ₉₅ Mn ₅
		400	10.4					(Co ₇₅ Fe ₂₅) ₉₈ Mn ₂	(Co ₇₅ Fe ₂₅) ₉₀ Mn ₁₀
34	b)	r.t.	22.8	Co ₉₀ Fe ₁₀	(Co ₉₀ Fe ₁₀) _{99.9} Re _{0.1}	(Co ₉₀ Fe ₁₀) _{99.8} Re _{0.2}	(Co ₇₅ Fe ₂₅) _{99.8} Re _{0.2}	(Co ₇₅ Fe ₂₅) _{99.9} Re _{0.1}	Co ₇₅ Fe ₂₅
		260	34.3						
		300	34.7						
		350	23.4					(Co ₇₅ Fe ₂₅) ₉₉ Re _{0.1} Mn _{0.9}	(Co ₇₅ Fe ₂₅) ₉₅ Mn ₅
		400	11.8					(Co ₇₅ Fe ₂₅) _{98.1} Re _{0.1} Mn _{1.8}	(Co ₇₅ Fe ₂₅) ₉₀ Mn ₁₀
35	b)	r.t.	21.9	Co ₉₀ Fe ₁₀	(Co ₉₀ Fe ₁₀) _{99.85} Re _{0.15}	(Co ₉₀ Fe ₁₀) _{99.7} Re _{0.3}	(Co ₇₅ Fe ₂₅) _{99.7} Re _{0.3}	(Co ₇₅ Fe ₂₅) _{99.85} Re _{0.15}	Co ₇₅ Fe ₂₅
		260	33.6						
		300	34.5						
		350	35.1					(Co ₇₅ Fe ₂₅) _{99.05} Re _{0.15} Mn _{0.8}	(Co ₇₅ Fe ₂₅) ₉₅ Mn ₅
		400	33.6					(Co ₇₅ Fe ₂₅) _{98.25} Re _{0.15} Mn _{1.6}	(Co ₇₅ Fe ₂₅) ₉₀ Mn ₁₀
36	b)	r.t.	20.5	Co ₉₀ Fe ₁₀	(Co ₉₀ Fe ₁₀) _{98.5} Re _{1.5}	(Co ₉₀ Fe ₁₀) ₉₇ Re ₃	(Co ₇₅ Fe ₂₅) ₉₇ Re ₃	(Co ₇₅ Fe ₂₅) _{98.5} Re _{1.5}	Co ₇₅ Fe ₂₅
		260	32.7						
		300	33.9						
		350	35.2					(Co ₇₅ Fe ₂₅) _{97.2} Re _{0.15} Mn _{0.7}	(Co ₇₅ Fe ₂₅) ₉₅ Mn ₅
		400	35.3					(Co ₇₅ Fe ₂₅) _{97.1} Re _{1.5} Mn _{1.4}	(Co ₇₅ Fe ₂₅) ₉₀ Mn ₁₀

[0055] continued

[Table 8] continued

TABLE 5a)-2

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
37	b)	r.t.	20.1	Co ₉₀ Fe ₁₀	(Co ₉₀ Fe ₁₀) _{92.5} Re _{7.5}	(Co ₉₀ Fe ₁₀) ₈₅ Re ₁₅	(Co ₇₅ Fe ₂₅) ₈₅ Re ₁₅	(Co ₇₅ Fe ₂₅) _{92.5} Re _{7.5}	Co ₇₅ Fe ₂₅
		260	30.7					(Co ₇₅ Fe ₂₅) ₉₂ Re _{7.5} Mn _{0.5}	(Co ₇₅ Fe ₂₅) ₉₅ Mn ₅
		300	33.4						
		350	35.3						
		400	37.6					(Co ₇₅ Fe ₂₅) _{91.5} Re _{7.4} Mn ₁	(Co ₇₅ Fe ₂₅) ₉₀ Mn ₁₀
38	b)	r.t.	22.4	Co ₉₀ Fe ₁₀	(Co ₉₀ Fe ₁₀) _{85.5} Re _{14.5}	(Co ₉₀ Fe ₁₀) ₇₁ Re ₂₉	(Co ₇₅ Fe ₂₅) ₇₁ Re ₂₉	(Co ₇₅ Fe ₂₅) _{85.5} Re _{14.5}	Co ₇₅ Fe ₂₅
		260	32.9					(Co ₇₅ Fe ₂₅) _{85.1} Re _{14.4} Mn _{0.5}	(Co ₇₅ Fe ₂₅) ₉₅ Mn ₅
		300	34.3						
		350	35.1						
		400	35.1					(Co ₇₅ Fe ₂₅) _{84.6} Re _{14.4} Mn ₁	(Co ₇₅ Fe ₂₅) ₉₀ Mn ₁₀
39	b)	r.t.	18.3	Co ₉₀ Fe ₁₀	(Co ₉₀ Fe ₁₀) _{70.5} Re _{29.5}	(Co ₉₀ Fe ₁₀) ₄₁ Re ₅₉	(Co ₇₅ Fe ₂₅) ₄₁ Re ₅₉	(Co ₇₅ Fe ₂₅) _{70.5} Re _{29.5}	Co ₇₅ Fe ₂₅
		260	31.2					(Co ₇₅ Fe ₂₅) _{70.1} Re _{29.4} Mn _{0.5}	(Co ₇₅ Fe ₂₅) ₉₅ Mn ₅
		300	32.6						
		350	33						
		400	32.5					(Co ₇₅ Fe ₂₅) _{69.8} Re _{29.2} Mn ₁	(Co ₇₅ Fe ₂₅) ₉₀ Mn ₁₀
40	b)	r.t.	13.8	Co ₉₀ Fe ₁₀	(Co ₉₀ Fe ₁₀) ₆₃ Re ₃₇	(Co ₉₀ Fe ₁₀) ₃₈ Re ₆₂	(Co ₇₅ Fe ₂₅) ₃₈ Re ₆₂	(Co ₇₅ Fe ₂₅) ₆₃ Re ₃₇	Co ₇₅ Fe ₂₅
		260	24.9					(Co ₇₅ Fe ₂₅) _{63.7} Re _{30.8} Mn _{0.5}	(Co ₇₅ Fe ₂₅) ₉₅ Mn ₅
		300	26.2						
		350	15.4						
		400	9.7					(Co ₇₅ Fe ₂₅) _{63.3} Re _{30.7} Mn ₁	(Co ₇₅ Fe ₂₅) ₉₀ Mn ₁₀

[0056]

[Table 9]

TABLE 5b)-1

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
41	c)	rt.	18	Ni ₈₀ Fe ₂₀	Ni ₈₀ Fe ₂₀	Ni ₈₀ Fe ₄₀	Ni ₈₀ Fe ₄₀	Co ₇₀ Fe ₃₀	Co
		260	37.8						
		300	40.3						
		350	24.6						
		400	12.2						
42	c)	rt.	16.8	Ni ₈₀ Fe ₂₀	(Ni ₈₀ Fe ₂₀) _{99.9} Ru _{0.1}	(Ni ₈₀ Fe ₄₀) _{99.8} Ru _{0.2}	(Ni ₈₀ Fe ₄₀) _{99.8} Os _{0.2}	(Co ₇₀ Fe ₃₀) _{99.8} Os _{0.2}	Co _{99.8} Os _{0.2}
		260	36.5					(Co ₇₀ Fe ₃₀) ₉₉ Os _{0.2} Mn _{0.8}	Co _{99.8} Os _{0.2} Mn _{0.4}
		300	37.7					(Co ₇₀ Fe ₃₀) ₉₈ Os _{0.2} Mn _{1.8}	Co _{99.8} Os _{0.2} Mn _{0.9}
		350	25.4						
		400	12.9						
43	c)	rt.	16.5	Ni ₈₀ Fe ₂₀	(Ni ₈₀ Fe ₂₀) _{99.85} Ru _{0.15}	(Ni ₈₀ Fe ₄₀) _{99.7} Ru _{0.3}	(Ni ₈₀ Fe ₄₀) _{99.7} Os _{0.3}	(Co ₇₀ Fe ₃₀) _{99.7} Os _{0.3}	Co _{99.7} Os _{0.3}
		260	36.4					(Co ₇₀ Fe ₃₀) _{98.9} Os _{0.3} Mn _{0.8}	Co _{99.7} Os _{0.3} Mn _{0.4}
		300	38.1					(Co ₇₀ Fe ₃₀) _{97.9} Os _{0.3} Mn _{1.8}	Co _{99.7} Os _{0.3} Mn _{0.9}
		350	35.9						
		400	30.5						
44	c)	rt.	16.3	Ni ₈₀ Fe ₂₀	(Ni ₈₀ Fe ₂₀) _{98.5} Ru _{1.5}	(Ni ₈₀ Fe ₄₀) ₉₇ Ru ₃	(Ni ₈₀ Fe ₄₀) ₉₇ Os ₃	(Co ₇₀ Fe ₃₀) ₉₇ Os ₃	Co ₉₇ Os ₃
		260	35.1					(Co ₇₀ Fe ₃₀) _{96.3} Os ₃ Mn _{0.7}	Co _{98.3} Os _{2.9} Mn _{3.8}
		300	35.9					(Co ₇₀ Fe ₃₀) _{95.4} Os _{2.9} Mn _{1.7}	Co _{98.5} Os _{2.7} Mn _{8.8}
		350	38.2						
		400	37.9						

[0056] continued

[Table 9] continued

TABLE 5b)-2

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
45	c)	r.t.	15.5	Ni ₈₀ Fe ₂₀	(Ni ₈₀ Fe ₂₀) _{92.5} Ru _{7.5}	(Ni ₈₀ Fe ₄₀) ₈₅ Ru ₁₅	(Ni ₈₀ Fe ₄₀) ₈₅ Os ₁₅	(Co ₇₀ Fe ₃₀) ₈₅ Os ₁₅	Co ₈₅ Os ₁₅
		260	30.6						
		300	32.3						
		350	35.4					(Co ₇₀ Fe ₃₀) _{84.5} Os _{14.5} Mn _{0.5}	Co _{81.9} Os _{14.5} Mn _{3.6}
		400	38.3					(Co ₇₀ Fe ₃₀) _{83.9} Os _{14.8} Mn _{1.3}	Co _{77.5} Os _{13.7} Mn _{8.4}
46	c)	r.t.	17.6	Ni ₈₀ Fe ₂₀	(Ni ₈₀ Fe ₂₀) _{85.5} Ru _{14.5}	(Ni ₈₀ Fe ₄₀) ₇₁ Ru ₂₉	(Ni ₈₀ Fe ₄₀) ₇₁ Os ₂₉	(Co ₇₀ Fe ₃₀) ₇₁ Os ₂₉	Co ₇₁ Os ₂₉
		260	32						
		300	33.1						
		350	34.3					(Co ₇₀ Fe ₃₀) _{70.6} Os _{29.9} Mn _{0.5}	Co _{68.4} Os ₂₈ Mn _{3.6}
		400	35.1					(Co ₇₀ Fe ₃₀) _{70.1} Os _{28.6} Mn _{1.3}	Co ₆₅ Os _{26.6} Mn _{8.4}
47	c)	r.t.	11.7	Ni ₈₀ Fe ₂₀	(Ni ₈₀ Fe ₂₀) _{70.5} Ru _{29.5}	(Ni ₈₀ Fe ₄₀) ₄₁ Ru ₅₉	(Ni ₈₀ Fe ₄₀) ₄₁ Os ₅₉	(Co ₇₀ Fe ₃₀) ₄₁ Os ₅₉	Co ₄₁ Os ₅₉
		260	30.3						
		300	32.4						
		350	32.2					(Co ₇₀ Fe ₃₀) _{40.8} Os _{58.7} Mn _{0.5}	Co _{39.5} Os _{56.9} Mn _{3.6}
		400	30.8					(Co ₇₀ Fe ₃₀) _{40.5} Os _{58.2} Mn _{1.3}	Co _{37.6} Os _{56.4} Mn _{8.4}
48	c)	r.t.	9.5	Ni ₈₀ Fe ₂₀	(Ni ₈₀ Fe ₂₀) ₆₈ Ru ₃₁	(Ni ₈₀ Fe ₄₀) ₃₈ Ru ₆₂	(Ni ₈₀ Fe ₄₀) ₃₈ Os ₆₂	(Co ₇₀ Fe ₃₀) ₃₈ Os ₆₂	Co ₃₈ Os ₆₂
		260	15.2						
		300	18.1						
		350	15.6					(Co ₇₀ Fe ₃₀) _{37.8} Os _{61.7} Mn _{0.5}	Co _{36.6} Os _{59.8} Mn _{3.6}
		400	11.7					(Co ₇₀ Fe ₃₀) _{37.5} Os _{61.2} Mn _{1.3}	Co _{34.8} Os _{58.8} Mn _{8.4}

[0057]

[Table 10]

TABLE 5c)-1

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
49	c)	rt.	21.7	Co ₅₀ Fe ₁₀	Co ₅₀ Fe ₁₀	Co ₅₀ Fe ₁₀	Co ₇₅ Fe ₂₅	Co ₇₅ Fe ₂₅	Co ₅₀ Fe ₁₀
		260	36.3						
		300	38.1						
		350	24.5					(Co ₇₅ Fe ₂₅) ₉₉ Mn ₁	(Co ₇₅ Fe ₂₅) ₉₅ Mn ₅
		400	11.6					(Co ₇₅ Fe ₂₅) ₉₈ Mn ₂	(Co ₇₅ Fe ₂₅) ₉₀ Mn ₁₀
50	c)	rt.	22.2	Co ₅₀ Fe ₁₀	Co ₅₀ Fe ₁₀	Co ₅₀ Fe ₁₀	(Co ₇₅ Fe ₂₅) _{99.8} Pt _{0.1} Cu _{0.1}	(Co ₇₅ Fe ₂₅) _{99.8} Pt _{0.1} Cu _{0.1}	(Co ₇₅ Fe ₂₅) _{99.8} Pt _{0.1} Cu _{0.1}
		260	35.4						
		300	36.8						
		350	22.3					(Co ₇₅ Fe ₂₅) _{99.8} Pt _{0.1} Cu _{0.1} Mn ₁	(Co ₇₅ Fe ₂₅) _{99.8} Pt _{0.1} Cu _{0.1} Mn ₅
		400	13.2					(Co ₇₅ Fe ₂₅) _{97.8} Pt _{0.1} Cu _{0.1} Mn ₂	(Co ₇₅ Fe ₂₅) _{98.8} Pt _{0.1} Cu _{0.1} Mn ₁₀
51	c)	rt.	21.9	Co ₅₀ Fe ₁₀	Co ₅₀ Fe ₁₀	Co ₅₀ Fe ₁₀	(Co ₇₅ Fe ₂₅) _{99.7} Pt _{0.15} Cu _{0.15}	(Co ₇₅ Fe ₂₅) _{99.7} Pt _{0.15} Cu _{0.15}	(Co ₇₅ Fe ₂₅) _{99.7} Pt _{0.15} Cu _{0.15}
		260	35.1						
		300	36.6						
		350	35.4					(Co ₇₅ Fe ₂₅) _{98.8} Pt _{0.15} Cu _{0.15} Mn _{0.9}	(Co ₇₅ Fe ₂₅) _{94.5} Pt _{0.15} Cu _{0.15} Mn _{4.5}
		400	33.8					(Co ₇₅ Fe ₂₅) _{97.9} Pt _{0.15} Cu _{0.15} Mn _{1.8}	(Co ₇₅ Fe ₂₅) _{90.1} Pt _{0.15} Cu _{0.15} Mn _{9.6}
52	c)	rt.	20.2	Co ₅₀ Fe ₁₀	Co ₅₀ Fe ₁₀	Co ₅₀ Fe ₁₀	(Co ₇₅ Fe ₂₅) ₉₇ Pt _{1.5} Cu _{1.5}	(Co ₇₅ Fe ₂₅) ₉₇ Pt _{1.5} Cu _{1.5}	(Co ₇₅ Fe ₂₅) ₉₇ Pt _{1.5} Cu _{1.5}
		260	32.8						
		300	35.3						
		350	37.7					(Co ₇₅ Fe ₂₅) _{95.2} Pt _{1.5} Cu _{1.5} Mn _{0.8}	(Co ₇₅ Fe ₂₅) _{92.5} Pt _{1.5} Cu _{1.5} Mn _{4.5}
		400	38.1					(Co ₇₅ Fe ₂₅) _{95.4} Pt _{1.5} Cu _{1.5} Mn _{1.6}	(Co ₇₅ Fe ₂₅) _{88.1} Pt _{1.4} Cu _{1.3} Mn _{9.2}

[0057] continued

[Table 10] continued

TABLE 5c)-2

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
53	c)	rt.	19	Co ₉₀ Fe ₁₀	Co ₉₀ Fe ₁₀	Co ₉₀ Fe ₁₀	(Co ₇₅ Fe ₂₅) ₈₅ Pt _{17.5} Cu _{7.5}	(Co ₇₅ Fe ₂₅) ₈₅ Pt _{17.5} Cu _{7.5}	(Co ₇₅ Fe ₂₅) ₈₅ Pt _{17.5} Cu _{7.5}
		260	31.6						
		300	34.5						
		350	38.9					(Co ₇₅ Fe ₂₅) _{81.5} Pt _{17.5} Cu _{7.5} Mn _{0.5}	(Co ₇₅ Fe ₂₅) _{81.5} Pt _{17.5} Cu _{7.5} Mn _{0.4}
		400	41.3					(Co ₇₅ Fe ₂₅) _{81.2} Pt _{17.4} Cu _{7.4} Mn ₁	(Co ₇₅ Fe ₂₅) _{81.2} Pt _{16.9} Cu _{6.9} Mn _{0.8}
54	c)	rt.	15.8	Co ₉₀ Fe ₁₀	Co ₉₀ Fe ₁₀	Co ₉₀ Fe ₁₀	(Co ₇₅ Fe ₂₅) ₇₁ Pt _{14.5} Cu _{14.5}	(Co ₇₅ Fe ₂₅) ₇₁ Pt _{14.5} Cu _{14.5}	(Co ₇₅ Fe ₂₅) ₇₁ Pt _{14.5} Cu _{14.5}
		260	31.2						
		300	32.7						
		350	37.1					(Co ₇₅ Fe ₂₅) _{70.7} Pt _{14.4} Cu _{14.4} Mn _{0.5}	(Co ₇₅ Fe ₂₅) _{69.2} Pt _{13.9} Cu _{13.9} Mn _{0.4}
		400	36.8					(Co ₇₅ Fe ₂₅) _{70.2} Pt _{14.4} Cu _{14.4} Mn ₁	(Co ₇₅ Fe ₂₅) _{68.4} Pt _{13.5} Cu _{13.5} Mn _{0.8}
55	c)	rt.	15.4	Co ₉₀ Fe ₁₀	Co ₉₀ Fe ₁₀	Co ₉₀ Fe ₁₀	(Co ₇₅ Fe ₂₅) ₄₁ Pt _{23.5} Cu _{23.5}	(Co ₇₅ Fe ₂₅) ₄₁ Pt _{23.5} Cu _{23.5}	(Co ₇₅ Fe ₂₅) ₄₁ Pt _{23.5} Cu _{23.5}
		260	31						
		300	32.6						
		350	35.1					(Co ₇₅ Fe ₂₅) _{40.8} Pt _{23.4} Cu _{23.3} Mn _{0.5}	(Co ₇₅ Fe ₂₅) _{39.2} Pt _{23.9} Cu _{23.9} Mn _{0.4}
		400	33.8					(Co ₇₅ Fe ₂₅) _{40.5} Pt _{23.2} Cu _{23.2} Mn ₁	(Co ₇₅ Fe ₂₅) _{37.7} Pt _{21.2} Cu _{21.1} Mn _{0.8}
56	c)	rt.	11.8	Co ₉₀ Fe ₁₀	Co ₉₀ Fe ₁₀	Co ₉₀ Fe ₁₀	(Co ₇₅ Fe ₂₅) ₃₈ Pt ₃₁ Cu ₃₁	(Co ₇₅ Fe ₂₅) ₃₈ Pt ₃₁ Cu ₃₁	(Co ₇₅ Fe ₂₅) ₃₈ Pt ₃₁ Cu ₃₁
		260	24.9						
		300	24.7						
		350	14.9					(Co ₇₅ Fe ₂₅) _{37.9} Pt _{30.8} Cu _{30.8} Mn _{0.5}	(Co ₇₅ Fe ₂₅) _{35.4} Pt _{29.8} Cu _{29.8} Mn _{0.4}
		400	10.5					(Co ₇₅ Fe ₂₅) _{37.5} Pt _{30.7} Cu _{30.7} Mn ₁	(Co ₇₅ Fe ₂₅) ₃₅ Pt _{28.5} Cu _{28.5} Mn _{0.8}

[0058]

[Table 11]

TABLE 5d)-1

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
57	c)	rt.	12.7	Ni ₈₀ Fe ₂₀	Ni ₈₀ Fe ₂₀	Fe	Fe	Co ₇₅ Fe ₂₅	Co ₇₅ Fe ₂₅
		260	28.4						
		300	29.3						
		350	18.9				Fe _{99.8} Mn _{0.2}	(Co ₇₅ Fe ₂₅) ₉₀ Mn ₁₀	(Co ₇₅ Fe ₂₅) ₉₅ Mn ₅
		400	15.1					(Co ₇₅ Fe ₂₅) ₉₈ Mn ₂	(Co ₇₅ Fe ₂₅) ₉₀ Mn ₁₀
58	c)	rt.	12.7	Ni ₈₀ Fe ₂₀	Ni ₈₀ Fe ₂₀	Fe _{99.8} Pt _{0.2}	Fe _{99.8} Pt _{0.2}	Co ₇₅ Fe ₂₅	Co ₇₅ Fe ₂₅
		260	28.2						
		300	29.7						
		350	19.3				Fe _{99.8} Pt _{0.2} Mn _{0.2}	(Co ₇₅ Fe ₂₅) ₉₀ Mn ₁₀	(Co ₇₅ Fe ₂₅) ₉₅ Mn ₅
		400	15.4					(Co ₇₅ Fe ₂₅) ₉₈ Mn ₂	(Co ₇₅ Fe ₂₅) ₉₀ Mn ₁₀
59	c)	rt.	12.5	Ni ₈₀ Fe ₂₀	Ni ₈₀ Fe ₂₀	Fe _{99.7} Pt _{0.3}	Fe _{99.7} Pt _{0.3}	Co ₇₅ Fe ₂₅	Co ₇₅ Fe ₂₅
		260	27.1						
		300	29.4						
		350	27.2				Fe _{99.55} Pt _{0.3} Mn _{0.15}	(Co ₇₅ Fe ₂₅) ₉₀ Mn ₁₀	(Co ₇₅ Fe ₂₅) ₉₅ Mn ₅
		400	29					(Co ₇₅ Fe ₂₅) ₉₈ Mn ₂	(Co ₇₅ Fe ₂₅) ₉₀ Mn ₁₀
60	c)	rt.	12.3	Ni ₈₀ Fe ₂₀	Ni ₈₀ Fe ₂₀	Fe ₉₇ Pt ₃	Fe ₉₇ Pt ₃	Co ₇₅ Fe ₂₅	Co ₇₅ Fe ₂₅
		260	26.5						
		300	26.8						
		350	28.7				Fe _{96.9} Pt ₃ Mn _{0.1}	(Co ₇₅ Fe ₂₅) ₉₀ Mn ₁₀	(Co ₇₅ Fe ₂₅) ₉₅ Mn ₅
		400	30					(Co ₇₅ Fe ₂₅) ₉₈ Mn ₂	(Co ₇₅ Fe ₂₅) ₉₀ Mn ₁₀

[0058] continued

[Table 11] continued

TABLE 5d)-2

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
61	c)	r.t.	12.4	Ni ₈₀ Fe ₂₀	Ni ₈₀ Fe ₂₀	Fe ₈₅ Pt ₁₅	Fe ₈₅ Pt ₁₅	Co ₇₅ Fe ₂₅	Co ₇₅ Fe ₂₅
		260	23.9						
		300	25.1					(Co ₇₅ Fe ₂₅) ₉₃ Mn ₁	(Co ₇₅ Fe ₂₅) ₉₅ Mn ₅
		350	30.4						
		400	37					(Co ₇₅ Fe ₂₅) ₉₈ Mn ₂	(Co ₇₅ Fe ₂₅) ₉₀ Mn ₁₀
62	c)	r.t.	11.9	Ni ₈₀ Fe ₂₀	Ni ₈₀ Fe ₂₀	Fe ₇₁ Pt ₂₉	Fe ₇₁ Pt ₂₉	Co ₇₅ Fe ₂₅	Co ₇₅ Fe ₂₅
		260	25.1						
		300	27.8					(Co ₇₅ Fe ₂₅) ₉₃ Mn ₁	(Co ₇₅ Fe ₂₅) ₉₅ Mn ₅
		350	29.1						
		400	33.4					(Co ₇₅ Fe ₂₅) ₉₈ Mn ₂	(Co ₇₅ Fe ₂₅) ₉₀ Mn ₁₀
63	c)	r.t.	11.5	Ni ₈₀ Fe ₂₀	Ni ₈₀ Fe ₂₀	Fe ₄₁ Pt ₅₉	Fe ₄₁ Pt ₅₉	Co ₇₅ Fe ₂₅	Co ₇₅ Fe ₂₅
		260	24.9						
		300	27.4					(Co ₇₅ Fe ₂₅) ₉₃ Mn ₁	(Co ₇₅ Fe ₂₅) ₉₅ Mn ₅
		350	27.6						
		400	29.4					(Co ₇₅ Fe ₂₅) ₉₈ Mn ₂	(Co ₇₅ Fe ₂₅) ₉₀ Mn ₁₀
64	c)	r.t.	10.3	Ni ₈₀ Fe ₂₀	Ni ₈₀ Fe ₂₀	Fe ₃₃ Pt ₆₇	Fe ₃₃ Pt ₆₇	Co ₇₅ Fe ₂₅	Co ₇₅ Fe ₂₅
		260	21						
		300	22.1					(Co ₇₅ Fe ₂₅) ₉₃ Mn ₁	(Co ₇₅ Fe ₂₅) ₉₅ Mn ₅
		350	18.5						
		400	15.9					(Co ₇₅ Fe ₂₅) ₉₈ Mn ₂	(Co ₇₅ Fe ₂₅) ₉₀ Mn ₁₀

[0059]

Table 5a) shows the result of the case where Re is added to the vicinity of the interface in high concentration. In this case, similarly to the case of Table 4), increase of the MR characteristics after the heat treatment can be found, particularly when Re has a concentration of 3 to 29 at%. However, this effect can be obtained only in the case of adding Re at the interface between the ferromagnet and the non-magnet. Whereas, Re is not added to the vicinity of the interface with antiferromagnet, the Mn diffusion is not suppressed here. It is also obvious that, in the case of the type of the combination with the antiferromagnet, when control of adding of Mn and Cr is combined with to the additive effect with regard to the interface, a more useful effect as elements can be obtained. Here, the same tendency can be obtained by replacing Re with Ru, Os, Rh, Ir, Pd, Pt, Cu, Au or the like. Moreover, the same tendency can be obtained by modifying the ferromagnets to the compositions used in Table 4).

[0060]

In the samples shown in Table 5b), another element is added to both sides of the non-magnet. This can provide the same effect as well. Moreover, the same effect can be obtained by replacing Ru in Table 5b) with Tc, Re, Rh, Ir, Pd, Pt, Ag or Au and replacing Os with Tc, Re, Rh, Ir, Pd, Pt, Cu or Au. The modification of the ferromagnets to the compositions used in Table 4) also can provide the same tendency.

[0061]

In the samples shown in Table 5c), Pt and Cu are added only to one of the interfaces of the non-magnet. This can provide the same tendency as well. Moreover, the same tendency can be obtained by replacing (Pt, Cu) in Table 5c) with Tc, Re, Rh, Ir, Pd, Pt, Ag, Au, (Ru, Ir), (Pt, Pd), (Pt, Au), (Ir, Rh), (Ru, Pd), (Tc, Re, Ag), (Ru, Os, Ir), (Rh, Ir, Pt), (Pd, Pt, Cu), (Cu, Ag, Au), (Re, Ru, Os), (Ru, Rh, Pd), (Ir, Pt, Cu) or (Re, Ir, Ag). The modification of the ferromagnets to the compositions used in Table 4) also can provide the same tendency.

[0062]

Tables 5d) to 8a) show the results obtained when Mn and Pt are added. Table 5d) corresponds to the addition of Mn in an amount of zero at%. Tables 6a) to 8a) show the results of a change in amount of Pt according to the addition of Mn in an amount of 0.2, 0.5, 1, 2, 5, 8, 12, 19 or 22 at%.

[0063]

[Table 12]

TABLE 6a)-1

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
65	c)	r.t.	12.6	$(\text{Ni}_{80}\text{Fe}_{20})_{99.8}\text{Mn}_{0.2}$	$(\text{Ni}_{80}\text{Fe}_{20})_{99.8}\text{Mn}_{0.2}$	$\text{Fe}_{99.8}\text{Mn}_{0.2}$	$\text{Fe}_{99.8}\text{Mn}_{0.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.8}\text{Mn}_{0.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.8}\text{Mn}_{0.2}$
		260	28.5					$(\text{Co}_{75}\text{Fe}_{25})_{98.8}\text{Mn}_{1.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{94.8}\text{Mn}_{5.2}$
		300	29.1						
		350	18.9				$\text{Fe}_{99.6}\text{Mn}_{0.4}$	$(\text{Co}_{75}\text{Fe}_{25})_{97.8}\text{Mn}_{2.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.8}\text{Mn}_{10.2}$
		400	15.1						
66	c)	r.t.	12.8	$(\text{Ni}_{80}\text{Fe}_{20})_{99.8}\text{Mn}_{0.2}$	$(\text{Ni}_{80}\text{Fe}_{20})_{99.8}\text{Mn}_{0.2}$	$\text{Fe}_{99.6}\text{Pt}_{0.2}\text{Mn}_{0.2}$	$\text{Fe}_{99.6}\text{Pt}_{0.2}\text{Mn}_{0.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.8}\text{Mn}_{0.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.8}\text{Mn}_{0.2}$
		260	28.4					$(\text{Co}_{75}\text{Fe}_{25})_{98.8}\text{Mn}_{1.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{94.8}\text{Mn}_{5.2}$
		300	29.1						
		350	19.5						
		400	15.6						
67	c)	r.t.	12.7	$(\text{Ni}_{80}\text{Fe}_{20})_{99.8}\text{Mn}_{0.2}$	$(\text{Ni}_{80}\text{Fe}_{20})_{99.8}\text{Mn}_{0.2}$	$\text{Fe}_{99.5}\text{Pt}_{0.3}\text{Mn}_{0.2}$	$\text{Fe}_{99.5}\text{Pt}_{0.3}\text{Mn}_{0.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.8}\text{Mn}_{0.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.8}\text{Mn}_{0.2}$
		260	27.4					$(\text{Co}_{75}\text{Fe}_{25})_{98.8}\text{Mn}_{1.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{94.8}\text{Mn}_{5.2}$
		300	30.1						
		350	29.5						
		400	33.4						
68	c)	r.t.	12.5	$(\text{Ni}_{80}\text{Fe}_{20})_{99.8}\text{Mn}_{0.2}$	$(\text{Ni}_{80}\text{Fe}_{20})_{99.8}\text{Mn}_{0.2}$	$\text{Fe}_{97}\text{Pt}_{2.8}\text{Mn}_{0.2}$	$\text{Fe}_{97}\text{Pt}_{2.8}\text{Mn}_{0.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.8}\text{Mn}_{0.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.8}\text{Mn}_{0.2}$
		260	27					$(\text{Co}_{75}\text{Fe}_{25})_{98.8}\text{Mn}_{1.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{94.8}\text{Mn}_{5.2}$
		300	28.9						
		350	33.6						
		400	36.7						

[0063] continued

[Table 12] continued

TABLE 6a)-2

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
69	c)	r.t.	12.1	$(\text{Ni}_{80}\text{Fe}_{20})_{99.8}\text{Mn}_{0.2}$	$(\text{Ni}_{80}\text{Fe}_{20})_{99.8}\text{Mn}_{0.2}$	$\text{Fe}_{85}\text{Pt}_{14.5}\text{Mn}_{0.2}$	$\text{Fe}_{85}\text{Pt}_{14.5}\text{Mn}_{0.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.8}\text{Mn}_{0.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.8}\text{Mn}_{0.2}$
		260	25.3						
		300	29.9						
		350	34.2					$(\text{Co}_{75}\text{Fe}_{25})_{98.8}\text{Mn}_{1.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{94.8}\text{Mn}_{5.2}$
		400	39.6					$(\text{Co}_{75}\text{Fe}_{25})_{97.8}\text{Mn}_{2.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{89.8}\text{Mn}_{10.2}$
70	c)	r.t.	11.8	$(\text{Ni}_{80}\text{Fe}_{20})_{99.8}\text{Mn}_{0.2}$	$(\text{Ni}_{80}\text{Fe}_{20})_{99.8}\text{Mn}_{0.2}$	$\text{Fe}_{71}\text{Pt}_{28.8}\text{Mn}_{0.2}$	$\text{Fe}_{71}\text{Pt}_{28.8}\text{Mn}_{0.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.8}\text{Mn}_{0.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.8}\text{Mn}_{0.2}$
		260	25.3						
		300	27.4						
		350	31.8					$(\text{Co}_{75}\text{Fe}_{25})_{98.8}\text{Mn}_{1.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{94.8}\text{Mn}_{5.2}$
		400	37.9					$(\text{Co}_{75}\text{Fe}_{25})_{97.8}\text{Mn}_{2.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{89.8}\text{Mn}_{10.2}$
71	c)	r.t.	11.4	$(\text{Ni}_{80}\text{Fe}_{20})_{99.8}\text{Mn}_{0.2}$	$(\text{Ni}_{80}\text{Fe}_{20})_{99.8}\text{Mn}_{0.2}$	$\text{Fe}_{41}\text{Pt}_{58.8}\text{Mn}_{0.2}$	$\text{Fe}_{41}\text{Pt}_{58.8}\text{Mn}_{0.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.8}\text{Mn}_{0.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.8}\text{Mn}_{0.2}$
		260	25.1						
		300	27.1						
		350	28.5					$(\text{Co}_{75}\text{Fe}_{25})_{98.8}\text{Mn}_{1.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{94.8}\text{Mn}_{5.2}$
		400	34.2					$(\text{Co}_{75}\text{Fe}_{25})_{97.8}\text{Mn}_{2.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{89.8}\text{Mn}_{10.2}$
72	c)	r.t.	10.5	$(\text{Ni}_{80}\text{Fe}_{20})_{99.8}\text{Mn}_{0.2}$	$(\text{Ni}_{80}\text{Fe}_{20})_{99.8}\text{Mn}_{0.2}$	$\text{Fe}_{38}\text{Pt}_{61.8}\text{Mn}_{0.2}$	$\text{Fe}_{38}\text{Pt}_{61.8}\text{Mn}_{0.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.8}\text{Mn}_{0.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.8}\text{Mn}_{0.2}$
		260	20.5						
		300	22.3						
		350	18.7					$(\text{Co}_{75}\text{Fe}_{25})_{98.8}\text{Mn}_{1.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{94.8}\text{Mn}_{5.2}$
		400	16					$(\text{Co}_{75}\text{Fe}_{25})_{97.8}\text{Mn}_{2.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{89.8}\text{Mn}_{10.2}$

[0064]

[Table 13]

TABLE 6b)-1

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
73	c)	rt.	12.8	$(\text{Ni}_{80}\text{Fe}_{20})_{99.5}\text{Mn}_{0.5}$	$(\text{Ni}_{80}\text{Fe}_{20})_{99.5}\text{Mn}_{0.5}$	$\text{Fe}_{99.5}\text{Mn}_{0.5}$	$\text{Fe}_{99.5}\text{Mn}_{0.5}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.5}\text{Mn}_{0.5}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.5}\text{Mn}_{0.5}$
		260	28.6						
		300	28.9					$(\text{Co}_{75}\text{Fe}_{25})_{98.5}\text{Mn}_{1.5}$	$(\text{Co}_{75}\text{Fe}_{25})_{94.5}\text{Mn}_{5.5}$
		350	19.5						
		400	15.6				$\text{Fe}_{99.3}\text{Mn}_{0.7}$	$(\text{Co}_{75}\text{Fe}_{25})_{97.5}\text{Mn}_{2.5}$	$(\text{Co}_{75}\text{Fe}_{25})_{89.5}\text{Mn}_{10.4}$
74	c)	rt.	12.7	$(\text{Ni}_{80}\text{Fe}_{20})_{99.5}\text{Mn}_{0.5}$	$(\text{Ni}_{80}\text{Fe}_{20})_{99.5}\text{Mn}_{0.5}$	$\text{Fe}_{99.3}\text{Pt}_{0.2}\text{Mn}_{0.5}$	$\text{Fe}_{99.3}\text{Pt}_{0.2}\text{Mn}_{0.5}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.5}\text{Mn}_{0.5}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.5}\text{Mn}_{0.5}$
		260	28.6						
		300	29.5					$(\text{Co}_{75}\text{Fe}_{25})_{98.5}\text{Mn}_{1.5}$	$(\text{Co}_{75}\text{Fe}_{25})_{94.5}\text{Mn}_{5.5}$
		350	19.7						
		400	15.7				$\text{Fe}_{99.1}\text{Pt}_{0.2}\text{Mn}_{0.7}$	$(\text{Co}_{75}\text{Fe}_{25})_{97.5}\text{Mn}_{2.5}$	$(\text{Co}_{75}\text{Fe}_{25})_{89.5}\text{Mn}_{10.4}$
75	c)	rt.	12.4	$(\text{Ni}_{80}\text{Fe}_{20})_{99.5}\text{Mn}_{0.5}$	$(\text{Ni}_{80}\text{Fe}_{20})_{99.5}\text{Mn}_{0.5}$	$\text{Fe}_{99.2}\text{Pt}_{0.3}\text{Mn}_{0.5}$	$\text{Fe}_{99.2}\text{Pt}_{0.3}\text{Mn}_{0.5}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.5}\text{Mn}_{0.5}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.5}\text{Mn}_{0.5}$
		260	27.1						
		300	29.9					$(\text{Co}_{75}\text{Fe}_{25})_{98.5}\text{Mn}_{1.5}$	$(\text{Co}_{75}\text{Fe}_{25})_{94.5}\text{Mn}_{5.5}$
		350	28.4						
		400	30.8				$\text{Fe}_{99}\text{Pt}_{0.3}\text{Mn}_{0.7}$	$(\text{Co}_{75}\text{Fe}_{25})_{97.5}\text{Mn}_{2.5}$	$(\text{Co}_{75}\text{Fe}_{25})_{89.5}\text{Mn}_{10.4}$
76	c)	rt.	12.8	$(\text{Ni}_{80}\text{Fe}_{20})_{99.5}\text{Mn}_{0.5}$	$(\text{Ni}_{80}\text{Fe}_{20})_{99.5}\text{Mn}_{0.5}$	$\text{Fe}_{97}\text{Pt}_{2.5}\text{Mn}_{0.5}$	$\text{Fe}_{97}\text{Pt}_{2.5}\text{Mn}_{0.5}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.5}\text{Mn}_{0.5}$	$(\text{Co}_{75}\text{Fe}_{25})_{99.5}\text{Mn}_{0.5}$
		260	27.6						
		300	29.4					$(\text{Co}_{75}\text{Fe}_{25})_{98.5}\text{Mn}_{1.5}$	$(\text{Co}_{75}\text{Fe}_{25})_{94.5}\text{Mn}_{5.5}$
		350	34.4						
		400	37.7				$\text{Fe}_{96.86}\text{Pt}_{2.5}\text{Mn}_{0.65}$	$(\text{Co}_{75}\text{Fe}_{25})_{97.5}\text{Mn}_{2.5}$	$(\text{Co}_{75}\text{Fe}_{25})_{89.5}\text{Mn}_{10.4}$

[0064] continued

[Table 13] continued

TABLE 6b)-2

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
77	c)	r.t.	13.1	(Ni ₈₀ Fe ₂₀) _{99.5} Mn _{0.5}	(Ni ₈₀ Fe ₂₀) _{99.5} Mn _{0.5}	Fe ₈₅ Pt _{14.5} Mn _{0.5}	Fe ₈₆ Pt _{14.5} Mn _{0.5}	(Co ₇₅ Fe ₂₅) _{99.5} Mn _{0.5}	(Co ₇₅ Fe ₂₅) _{99.5} Mn _{0.5}
		260	26.7						
		300	31.2						
		350	38.4					(Co ₇₅ Fe ₂₅) _{98.5} Mn _{1.5}	(Co ₇₅ Fe ₂₅) _{94.5} Mn _{5.5}
		400	42.4				Fe _{84.9} Pt _{14.5} Mn _{0.6}	(Co ₇₅ Fe ₂₅) _{97.5} Mn _{2.5}	(Co ₇₅ Fe ₂₅) _{89.6} Mn _{10.4}
78	c)	r.t.	12.1	(Ni ₈₀ Fe ₂₀) _{99.5} Mn _{0.5}	(Ni ₈₀ Fe ₂₀) _{99.5} Mn _{0.5}	Fe ₇₁ Pt _{28.5} Mn _{0.5}	Fe ₇₁ Pt _{28.5} Mn _{0.5}	(Co ₇₅ Fe ₂₅) _{99.5} Mn _{0.5}	(Co ₇₅ Fe ₂₅) _{99.5} Mn _{0.5}
		260	25.5						
		300	27.1						
		350	37					(Co ₇₅ Fe ₂₅) _{98.5} Mn _{1.5}	(Co ₇₅ Fe ₂₅) _{94.5} Mn _{5.5}
		400	42.1					(Co ₇₅ Fe ₂₅) _{97.5} Mn _{2.5}	(Co ₇₅ Fe ₂₅) _{89.6} Mn _{10.4}
79	c)	r.t.	11.6	(Ni ₈₀ Fe ₂₀) _{99.5} Mn _{0.5}	(Ni ₈₀ Fe ₂₀) _{99.5} Mn _{0.5}	Fe ₄₁ Pt _{58.5} Mn _{0.5}	Fe ₄₁ Pt _{58.5} Mn _{0.5}	(Co ₇₅ Fe ₂₅) _{99.5} Mn _{0.5}	(Co ₇₅ Fe ₂₅) _{99.5} Mn _{0.5}
		260	24.9						
		300	26.8						
		350	33.8					(Co ₇₅ Fe ₂₅) _{98.5} Mn _{1.5}	(Co ₇₅ Fe ₂₅) _{94.5} Mn _{5.5}
		400	39					(Co ₇₅ Fe ₂₅) _{97.5} Mn _{2.5}	(Co ₇₅ Fe ₂₅) _{89.6} Mn _{10.4}
80	c)	r.t.	10.4	(Ni ₈₀ Fe ₂₀) _{99.5} Mn _{0.5}	(Ni ₈₀ Fe ₂₀) _{99.5} Mn _{0.5}	Fe ₃₈ Pt _{61.5} Mn _{0.5}	Fe ₃₈ Pt _{61.5} Mn _{0.5}	(Co ₇₅ Fe ₂₅) _{99.5} Mn _{0.5}	(Co ₇₅ Fe ₂₅) _{99.5} Mn _{0.5}
		260	19.9						
		300	22.5						
		350	19.5					(Co ₇₅ Fe ₂₅) _{98.5} Mn _{1.5}	(Co ₇₅ Fe ₂₅) _{94.5} Mn _{5.5}
		400	16.5					(Co ₇₅ Fe ₂₅) _{97.5} Mn _{2.5}	(Co ₇₅ Fe ₂₅) _{89.6} Mn _{10.4}

[0065]

[Table 14]

TABLE 6c)-1

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
81	c)	r.t.	12.7	$(\text{Ni}_{80}\text{Fe}_{20})_{99}\text{Mn}_1$	$(\text{Ni}_{80}\text{Fe}_{20})_{99}\text{Mn}_1$	$\text{Fe}_{99}\text{Mn}_1$	$\text{Fe}_{99}\text{Mn}_1$	$(\text{Co}_{75}\text{Fe}_{25})_{99}\text{Mn}_1$	$(\text{Co}_{75}\text{Fe}_{25})_{99}\text{Mn}_1$
		260	28.4						
		300	28.6						
		350	18.9					$(\text{Co}_{75}\text{Fe}_{25})_{98}\text{Mn}_2$	$(\text{Co}_{75}\text{Fe}_{25})_{94.1}\text{Mn}_{5.9}$
		400	15.1				$\text{Fe}_{99.8}\text{Mn}_{1.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{97}\text{Mn}_3$	$(\text{Co}_{75}\text{Fe}_{25})_{89.1}\text{Mn}_{10.9}$
82	c)	r.t.	12.5	$(\text{Ni}_{80}\text{Fe}_{20})_{99}\text{Mn}_1$	$(\text{Ni}_{80}\text{Fe}_{20})_{99}\text{Mn}_1$	$\text{Fe}_{98.8}\text{Pt}_{0.2}\text{Mn}_1$	$\text{Fe}_{98.8}\text{Pt}_{0.2}\text{Mn}_1$	$(\text{Co}_{75}\text{Fe}_{25})_{99}\text{Mn}_1$	$(\text{Co}_{75}\text{Fe}_{25})_{99}\text{Mn}_1$
		260	28.3						
		300	29.6						
		350	19.09					$(\text{Co}_{75}\text{Fe}_{25})_{98}\text{Mn}_2$	$(\text{Co}_{75}\text{Fe}_{25})_{94.1}\text{Mn}_{5.9}$
		400	15.3				$\text{Fe}_{98.6}\text{Pt}_{0.2}\text{Mn}_{1.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{97}\text{Mn}_3$	$(\text{Co}_{75}\text{Fe}_{25})_{89.1}\text{Mn}_{10.9}$
83	c)	r.t.	12.1	$(\text{Ni}_{80}\text{Fe}_{20})_{99}\text{Mn}_1$	$(\text{Ni}_{80}\text{Fe}_{20})_{99}\text{Mn}_1$	$\text{Fe}_{98.7}\text{Pt}_{0.3}\text{Mn}_1$	$\text{Fe}_{98.7}\text{Pt}_{0.3}\text{Mn}_1$	$(\text{Co}_{75}\text{Fe}_{25})_{99}\text{Mn}_1$	$(\text{Co}_{75}\text{Fe}_{25})_{99}\text{Mn}_1$
		260	26.9						
		300	29.5						
		350	27.4					$(\text{Co}_{75}\text{Fe}_{25})_{98}\text{Mn}_2$	$(\text{Co}_{75}\text{Fe}_{25})_{94.1}\text{Mn}_{5.9}$
		400	28.8				$\text{Fe}_{98.5}\text{Pt}_{0.3}\text{Mn}_{1.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{97}\text{Mn}_3$	$(\text{Co}_{75}\text{Fe}_{25})_{89.1}\text{Mn}_{10.9}$
84	c)	r.t.	12.5	$(\text{Ni}_{80}\text{Fe}_{20})_{99}\text{Mn}_1$	$(\text{Ni}_{80}\text{Fe}_{20})_{99}\text{Mn}_1$	$\text{Fe}_{97}\text{Pt}_2\text{Mn}_1$	$\text{Fe}_{97}\text{Pt}_2\text{Mn}_1$	$(\text{Co}_{75}\text{Fe}_{25})_{99}\text{Mn}_1$	$(\text{Co}_{75}\text{Fe}_{25})_{99}\text{Mn}_1$
		260	27.4						
		300	29.6						
		350	33.3					$(\text{Co}_{75}\text{Fe}_{25})_{98}\text{Mn}_2$	$(\text{Co}_{75}\text{Fe}_{25})_{94.1}\text{Mn}_{5.9}$
		400	36.2				$\text{Fe}_{96.86}\text{Pt}_2\text{Mn}_{1.15}$	$(\text{Co}_{75}\text{Fe}_{25})_{97}\text{Mn}_3$	$(\text{Co}_{75}\text{Fe}_{25})_{89.1}\text{Mn}_{10.9}$

[0065] continued

[Table 14] continued

TABLE 6c)-2

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
85	c)	r.t.	13.3	(Ni ₈₀ Fe ₂₀) ₉₉ Mn ₁	(Ni ₈₀ Fe ₂₀) ₉₉ Mn ₁	Fe ₈₅ Pt ₁₄ Mn ₁	Fe ₈₅ Pt ₁₄ Mn ₁	(Co ₇₅ Fe ₂₅) ₉₉ Mn ₁	(Co ₇₅ Fe ₂₅) ₉₉ Mn ₁
		260	26.8						
		300	31.5						
		350	39.1				Fe _{84.9} Pt ₁₄ Mn _{1.1}	(Co ₇₅ Fe ₂₅) ₉₈ Mn ₂	(Co ₇₅ Fe ₂₅) _{94.1} Mn _{5.9}
		400	43.8					(Co ₇₅ Fe ₂₅) ₉₇ Mn ₃	(Co ₇₅ Fe ₂₅) _{89.1} Mn _{10.9}
86	c)	r.t.	12.1	(Ni ₈₀ Fe ₂₀) ₉₉ Mn ₁	(Ni ₈₀ Fe ₂₀) ₉₉ Mn ₁	Fe ₇₁ Pt ₂₈ Mn ₁	Fe ₇₁ Pt ₂₈ Mn ₁	(Co ₇₅ Fe ₂₅) ₉₉ Mn ₁	(Co ₇₅ Fe ₂₅) ₉₉ Mn ₁
		260	25.6						
		300	27						
		350	37					(Co ₇₅ Fe ₂₅) ₉₈ Mn ₂	(Co ₇₅ Fe ₂₅) _{94.1} Mn _{5.9}
		400	42.4					(Co ₇₅ Fe ₂₅) ₉₇ Mn ₃	(Co ₇₅ Fe ₂₅) _{89.1} Mn _{10.9}
87	c)	r.t.	11.7	(Ni ₈₀ Fe ₂₀) ₉₉ Mn ₁	(Ni ₈₀ Fe ₂₀) ₉₉ Mn ₁	Fe ₄₁ Pt ₅₈ Mn ₁	Fe ₄₁ Pt ₅₈ Mn ₁	(Co ₇₅ Fe ₂₅) ₉₉ Mn ₁	(Co ₇₅ Fe ₂₅) ₉₉ Mn ₁
		260	25.1						
		300	26.9						
		350	34.8					(Co ₇₅ Fe ₂₅) ₉₈ Mn ₂	(Co ₇₅ Fe ₂₅) _{94.1} Mn _{5.9}
		400	39.4					(Co ₇₅ Fe ₂₅) ₉₇ Mn ₃	(Co ₇₅ Fe ₂₅) _{89.1} Mn _{10.9}
88	c)	r.t.	10.5	(Ni ₈₀ Fe ₂₀) ₉₉ Mn ₁	(Ni ₈₀ Fe ₂₀) ₉₉ Mn ₁	Fe ₃₈ Pt ₆₁ Mn ₁	Fe ₃₈ Pt ₆₁ Mn ₁	(Co ₇₅ Fe ₂₅) ₉₉ Mn ₁	(Co ₇₅ Fe ₂₅) ₉₉ Mn ₁
		260	19.8						
		300	22.6						
		350	19.7					(Co ₇₅ Fe ₂₅) ₉₈ Mn ₂	(Co ₇₅ Fe ₂₅) _{94.1} Mn _{5.9}
		400	16.6					(Co ₇₅ Fe ₂₅) ₉₇ Mn ₃	(Co ₇₅ Fe ₂₅) _{89.1} Mn _{10.9}

[0066]

[Table 15]

TABLE 6d)-1

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
89	c)	r.t.	12.5	(Ni ₈₀ Fe ₂₀) ₉₈ Mn ₂	(Ni ₈₀ Fe ₂₀) ₉₈ Mn ₂	Fe ₉₈ Mn ₂	Fe ₉₈ Mn ₂	(Co ₇₅ Fe ₂₅) ₉₈ Mn ₂	(Co ₇₅ Fe ₂₅) ₉₈ Mn ₂
		260	28.2					(Co ₇₅ Fe ₂₅) ₉₇ Mn ₃	(Co ₇₅ Fe ₂₅) _{93.1} Mn _{6.9}
		300	28.3						
		350	18.7						
		400	14.9				Fe _{97.8} Mn _{2.2}	(Co ₇₅ Fe ₂₅) ₉₆ Mn ₄	(Co ₇₅ Fe ₂₅) _{88.2} Mn _{11.8}
90	c)	r.t.	12.4	(Ni ₈₀ Fe ₂₀) ₉₈ Mn ₂	(Ni ₈₀ Fe ₂₀) ₉₈ Mn ₂	Fe _{97.8} Pt _{0.2} Mn ₂	Fe _{97.8} Pt _{0.2} Mn ₂	(Co ₇₅ Fe ₂₅) ₉₈ Mn ₂	(Co ₇₅ Fe ₂₅) ₉₈ Mn ₂
		260	28.1					(Co ₇₅ Fe ₂₅) ₉₇ Mn ₃	(Co ₇₅ Fe ₂₅) _{93.1} Mn _{6.9}
		300	29.1						
		350	18.9						
		400	15.1				Fe _{97.6} Pt _{0.2} Mn _{2.2}	(Co ₇₅ Fe ₂₅) ₉₆ Mn ₄	(Co ₇₅ Fe ₂₅) _{88.2} Mn _{11.8}
91	c)	r.t.	11.9	(Ni ₈₀ Fe ₂₀) ₉₈ Mn ₂	(Ni ₈₀ Fe ₂₀) ₉₈ Mn ₂	Fe _{97.7} Pt _{0.3} Mn ₂	Fe _{97.7} Pt _{0.3} Mn ₂	(Co ₇₅ Fe ₂₅) ₉₈ Mn ₂	(Co ₇₅ Fe ₂₅) ₉₈ Mn ₂
		260	26.6					(Co ₇₅ Fe ₂₅) ₉₇ Mn ₃	(Co ₇₅ Fe ₂₅) _{93.1} Mn _{6.9}
		300	29.1						
		350	27						
		400	28.4				Fe _{97.55} Pt _{0.3} Mn _{2.15}	(Co ₇₅ Fe ₂₅) ₉₆ Mn ₄	(Co ₇₅ Fe ₂₅) _{88.2} Mn _{11.8}
92	c)	r.t.	12.6	(Ni ₈₀ Fe ₂₀) ₉₈ Mn ₂	(Ni ₈₀ Fe ₂₀) ₉₈ Mn ₂	Fe ₉₆ Pt ₂ Mn ₂	Fe ₉₆ Pt ₂ Mn ₂	(Co ₇₅ Fe ₂₅) ₉₈ Mn ₂	(Co ₇₅ Fe ₂₅) ₉₈ Mn ₂
		260	27.7					(Co ₇₅ Fe ₂₅) ₉₇ Mn ₃	(Co ₇₅ Fe ₂₅) _{93.1} Mn _{6.9}
		300	30.2						
		350	32.9						
		400	35.8				Fe _{95.9} Pt ₂ Mn _{2.1}	(Co ₇₅ Fe ₂₅) ₉₆ Mn ₄	(Co ₇₅ Fe ₂₅) _{88.2} Mn _{11.8}

[0066] continued

[Table 15] continued

TABLE 6d)-2

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
93	c)	r.t.	13.5	$(\text{Ni}_{80}\text{Fe}_{20})_{98}\text{Mn}_2$	$(\text{Ni}_{80}\text{Fe}_{20})_{98}\text{Mn}_2$	$\text{Fe}_{85}\text{Pt}_{13}\text{Mn}_2$	$\text{Fe}_{85}\text{Pt}_{13}\text{Mn}_2$	$(\text{Co}_{75}\text{Fe}_{25})_{98}\text{Mn}_2$	$(\text{Co}_{75}\text{Fe}_{25})_{98}\text{Mn}_2$
		260	27.1					$(\text{Co}_{75}\text{Fe}_{25})_{97}\text{Mn}_3$	$(\text{Co}_{75}\text{Fe}_{25})_{99.1}\text{Mn}_{0.9}$
		300	32.2						
		350	40.6						
		400	46.8					$(\text{Co}_{75}\text{Fe}_{25})_{96}\text{Mn}_4$	$(\text{Co}_{75}\text{Fe}_{25})_{88.2}\text{Mn}_{11.8}$
94	c)	r.t.	12.4	$(\text{Ni}_{80}\text{Fe}_{20})_{98}\text{Mn}_2$	$(\text{Ni}_{80}\text{Fe}_{20})_{98}\text{Mn}_2$	$\text{Fe}_{71}\text{Pt}_{27}\text{Mn}_2$	$\text{Fe}_{71}\text{Pt}_{27}\text{Mn}_2$	$(\text{Co}_{75}\text{Fe}_{25})_{98}\text{Mn}_2$	$(\text{Co}_{75}\text{Fe}_{25})_{98}\text{Mn}_2$
		260	25.7					$(\text{Co}_{75}\text{Fe}_{25})_{97}\text{Mn}_3$	$(\text{Co}_{75}\text{Fe}_{25})_{99.1}\text{Mn}_{0.9}$
		300	28.1						
		350	38.6						
		400	44.5					$(\text{Co}_{75}\text{Fe}_{25})_{96}\text{Mn}_4$	$(\text{Co}_{75}\text{Fe}_{25})_{88.2}\text{Mn}_{11.8}$
95	c)	r.t.	11.9	$(\text{Ni}_{80}\text{Fe}_{20})_{98}\text{Mn}_2$	$(\text{Ni}_{80}\text{Fe}_{20})_{98}\text{Mn}_2$	$\text{Fe}_{41}\text{Pt}_{57}\text{Mn}_2$	$\text{Fe}_{41}\text{Pt}_{57}\text{Mn}_2$	$(\text{Co}_{75}\text{Fe}_{25})_{98}\text{Mn}_2$	$(\text{Co}_{75}\text{Fe}_{25})_{98}\text{Mn}_2$
		260	25.5					$(\text{Co}_{75}\text{Fe}_{25})_{97}\text{Mn}_3$	$(\text{Co}_{75}\text{Fe}_{25})_{99.1}\text{Mn}_{0.9}$
		300	27.1						
		350	37						
		400	42					$(\text{Co}_{75}\text{Fe}_{25})_{96}\text{Mn}_4$	$(\text{Co}_{75}\text{Fe}_{25})_{88.2}\text{Mn}_{11.8}$
96	c)	r.t.	10.4	$(\text{Ni}_{80}\text{Fe}_{20})_{98}\text{Mn}_2$	$(\text{Ni}_{80}\text{Fe}_{20})_{98}\text{Mn}_2$	$\text{Fe}_{38}\text{Pt}_{60}\text{Mn}_2$	$\text{Fe}_{38}\text{Pt}_{60}\text{Mn}_2$	$(\text{Co}_{75}\text{Fe}_{25})_{98}\text{Mn}_2$	$(\text{Co}_{75}\text{Fe}_{25})_{98}\text{Mn}_2$
		260	19.9					$(\text{Co}_{75}\text{Fe}_{25})_{97}\text{Mn}_3$	$(\text{Co}_{75}\text{Fe}_{25})_{99.1}\text{Mn}_{0.9}$
		300	22.4						
		350	19.8						
		400	16.8					$(\text{Co}_{75}\text{Fe}_{25})_{96}\text{Mn}_4$	$(\text{Co}_{75}\text{Fe}_{25})_{88.2}\text{Mn}_{11.8}$

[0067]

[Table 16]

TABLE 7a)-1

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
97	c)	r.t.	12.4	$(\text{Ni}_{80}\text{Fe}_{20})_{95}\text{Mn}_5$	$(\text{Ni}_{80}\text{Fe}_{20})_{95}\text{Mn}_5$	$\text{Fe}_{95}\text{Mn}_5$	$\text{Fe}_{95}\text{Mn}_5$	$(\text{Co}_{75}\text{Fe}_{25})_{95}\text{Mn}_5$	$(\text{Co}_{75}\text{Fe}_{25})_{95}\text{Mn}_5$
		260	28.3						
		300	28.4						
		350	18.5					$(\text{Co}_{75}\text{Fe}_{25})_{94.1}\text{Mn}_{5.9}$	$(\text{Co}_{75}\text{Fe}_{25})_{90.3}\text{Mn}_{9.7}$
		400	14.8				$\text{Fe}_{94.8}\text{Mn}_{5.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{93.1}\text{Mn}_{6.9}$	$(\text{Co}_{75}\text{Fe}_{25})_{85.5}\text{Mn}_{14.5}$
98	c)	r.t.	12.2	$(\text{Ni}_{80}\text{Fe}_{20})_{95}\text{Mn}_5$	$(\text{Ni}_{80}\text{Fe}_{20})_{95}\text{Mn}_5$	$\text{Fe}_{94.8}\text{Pt}_{0.2}\text{Mn}_5$	$\text{Fe}_{94.8}\text{Pt}_{0.2}\text{Mn}_5$	$(\text{Co}_{75}\text{Fe}_{25})_{95}\text{Mn}_5$	$(\text{Co}_{75}\text{Fe}_{25})_{95}\text{Mn}_5$
		260	28						
		300	28.9						
		350	18.7					$(\text{Co}_{75}\text{Fe}_{25})_{94.1}\text{Mn}_{5.9}$	$(\text{Co}_{75}\text{Fe}_{25})_{90.3}\text{Mn}_{9.7}$
		400	14.9				$\text{Fe}_{94.6}\text{Pt}_{0.2}\text{Mn}_{5.2}$	$(\text{Co}_{75}\text{Fe}_{25})_{93.1}\text{Mn}_{6.9}$	$(\text{Co}_{75}\text{Fe}_{25})_{85.5}\text{Mn}_{14.5}$
99	c)	r.t.	11.8	$(\text{Ni}_{80}\text{Fe}_{20})_{95}\text{Mn}_5$	$(\text{Ni}_{80}\text{Fe}_{20})_{95}\text{Mn}_5$	$\text{Fe}_{94.7}\text{Pt}_{0.3}\text{Mn}_5$	$\text{Fe}_{94.7}\text{Pt}_{0.3}\text{Mn}_5$	$(\text{Co}_{75}\text{Fe}_{25})_{95}\text{Mn}_5$	$(\text{Co}_{75}\text{Fe}_{25})_{95}\text{Mn}_5$
		260	26.4						
		300	28.8						
		350	26.5					$(\text{Co}_{75}\text{Fe}_{25})_{94.1}\text{Mn}_{5.9}$	$(\text{Co}_{75}\text{Fe}_{25})_{90.3}\text{Mn}_{9.7}$
		400	27.9				$\text{Fe}_{94.55}\text{Pt}_{0.3}\text{Mn}_{5.15}$	$(\text{Co}_{75}\text{Fe}_{25})_{93.1}\text{Mn}_{6.9}$	$(\text{Co}_{75}\text{Fe}_{25})_{85.5}\text{Mn}_{14.5}$
100	c)	r.t.	12.4	$(\text{Ni}_{80}\text{Fe}_{20})_{95}\text{Mn}_5$	$(\text{Ni}_{80}\text{Fe}_{20})_{95}\text{Mn}_5$	$\text{Fe}_{93}\text{Pt}_2\text{Mn}_5$	$\text{Fe}_{93}\text{Pt}_2\text{Mn}_5$	$(\text{Co}_{75}\text{Fe}_{25})_{95}\text{Mn}_5$	$(\text{Co}_{75}\text{Fe}_{25})_{95}\text{Mn}_5$
		260	27.1						
		300	29.9						
		350	31.6					$(\text{Co}_{75}\text{Fe}_{25})_{94.1}\text{Mn}_{5.9}$	$(\text{Co}_{75}\text{Fe}_{25})_{90.3}\text{Mn}_{9.7}$
		400	32.8				$\text{Fe}_{92.9}\text{Pt}_2\text{Mn}_{5.1}$	$(\text{Co}_{75}\text{Fe}_{25})_{93.1}\text{Mn}_{6.9}$	$(\text{Co}_{75}\text{Fe}_{25})_{85.5}\text{Mn}_{14.5}$

[0067] continued

[Table 16] continued

TABLE 7a)-2

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
101	c)	rt.	13.3	$(\text{Ni}_{80}\text{Fe}_{20})_{95}\text{Mn}_5$	$(\text{Ni}_{80}\text{Fe}_{20})_{95}\text{Mn}_5$	$\text{Fe}_{85}\text{Pt}_{10}\text{Mn}_5$	$\text{Fe}_{85}\text{Pt}_{10}\text{Mn}_5$	$(\text{Co}_{75}\text{Fe}_{25})_{95}\text{Mn}_5$	$(\text{Co}_{75}\text{Fe}_{25})_{95}\text{Mn}_5$
		260	26.9					$(\text{Co}_{75}\text{Fe}_{25})_{94.1}\text{Mn}_{5.9}$	$(\text{Co}_{75}\text{Fe}_{25})_{90.3}\text{Mn}_{9.7}$
		300	31.8						
		350	40.1						
		400	45					$(\text{Co}_{75}\text{Fe}_{25})_{93.1}\text{Mn}_{6.9}$	$(\text{Co}_{75}\text{Fe}_{25})_{85.5}\text{Mn}_{14.5}$
102	c)	rt.	12.2	$(\text{Ni}_{80}\text{Fe}_{20})_{95}\text{Mn}_5$	$(\text{Ni}_{80}\text{Fe}_{20})_{95}\text{Mn}_5$	$\text{Fe}_{71}\text{Pt}_{24}\text{Mn}_5$	$\text{Fe}_{71}\text{Pt}_{24}\text{Mn}_5$	$(\text{Co}_{75}\text{Fe}_{25})_{95}\text{Mn}_5$	$(\text{Co}_{75}\text{Fe}_{25})_{95}\text{Mn}_5$
		260	25.8					$(\text{Co}_{75}\text{Fe}_{25})_{94.1}\text{Mn}_{5.9}$	$(\text{Co}_{75}\text{Fe}_{25})_{90.3}\text{Mn}_{9.7}$
		300	27.9						
		350	36.7						
		400	43.2					$(\text{Co}_{75}\text{Fe}_{25})_{93.1}\text{Mn}_{6.9}$	$(\text{Co}_{75}\text{Fe}_{25})_{85.5}\text{Mn}_{14.5}$
103	c)	rt.	11.7	$(\text{Ni}_{80}\text{Fe}_{20})_{95}\text{Mn}_5$	$(\text{Ni}_{80}\text{Fe}_{20})_{95}\text{Mn}_5$	$\text{Fe}_{41}\text{Pt}_{64}\text{Mn}_5$	$\text{Fe}_{41}\text{Pt}_{64}\text{Mn}_5$	$(\text{Co}_{75}\text{Fe}_{25})_{95}\text{Mn}_5$	$(\text{Co}_{75}\text{Fe}_{25})_{95}\text{Mn}_5$
		260	25.3					$(\text{Co}_{75}\text{Fe}_{25})_{94.1}\text{Mn}_{5.9}$	$(\text{Co}_{75}\text{Fe}_{25})_{90.3}\text{Mn}_{9.7}$
		300	26.9						
		350	34.4						
		400	40.5					$(\text{Co}_{75}\text{Fe}_{25})_{93.1}\text{Mn}_{6.9}$	$(\text{Co}_{75}\text{Fe}_{25})_{85.5}\text{Mn}_{14.5}$
104	c)	rt.	10.3	$(\text{Ni}_{80}\text{Fe}_{20})_{95}\text{Mn}_5$	$(\text{Ni}_{80}\text{Fe}_{20})_{95}\text{Mn}_5$	$\text{Fe}_{38}\text{Pt}_{67}\text{Mn}_5$	$\text{Fe}_{38}\text{Pt}_{67}\text{Mn}_5$	$(\text{Co}_{75}\text{Fe}_{25})_{95}\text{Mn}_5$	$(\text{Co}_{75}\text{Fe}_{25})_{95}\text{Mn}_5$
		260	19.9					$(\text{Co}_{75}\text{Fe}_{25})_{94.1}\text{Mn}_{5.9}$	$(\text{Co}_{75}\text{Fe}_{25})_{90.3}\text{Mn}_{9.7}$
		300	22.2						
		350	19.5						
		400	16.5					$(\text{Co}_{75}\text{Fe}_{25})_{93.1}\text{Mn}_{6.9}$	$(\text{Co}_{75}\text{Fe}_{25})_{85.5}\text{Mn}_{14.5}$

[0068]

[Table 17]

TABLE 7b)-1

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
105	c)	rt.	12.1	$(\text{Ni}_{80}\text{Fe}_{20})_{92}\text{Mn}_8$	$(\text{Ni}_{80}\text{Fe}_{20})_{92}\text{Mn}_8$	$\text{Fe}_{92}\text{Mn}_8$	$\text{Fe}_{92}\text{Mn}_8$	$(\text{Co}_{75}\text{Fe}_{25})_{92}\text{Mn}_8$	$(\text{Co}_{75}\text{Fe}_{25})_{92}\text{Mn}_8$
		260	27.6						
		300	27.8					$(\text{Co}_{75}\text{Fe}_{25})_{91.2}\text{Mn}_{8.8}$	$(\text{Co}_{75}\text{Fe}_{25})_{87.9}\text{Mn}_{12.1}$
		350	18						
		400	14.3				$\text{Fe}_{91.85}\text{Mn}_{8.15}$	$(\text{Co}_{75}\text{Fe}_{25})_{90.3}\text{Mn}_{9.7}$	$(\text{Co}_{75}\text{Fe}_{25})_{83.7}\text{Mn}_{16.3}$
106	c)	rt.	12.2	$(\text{Ni}_{80}\text{Fe}_{20})_{92}\text{Mn}_8$	$(\text{Ni}_{80}\text{Fe}_{20})_{92}\text{Mn}_8$	$\text{Fe}_{91.8}\text{Pt}_{0.2}\text{Mn}_8$	$\text{Fe}_{91.8}\text{Pt}_{0.2}\text{Mn}_8$	$(\text{Co}_{75}\text{Fe}_{25})_{92}\text{Mn}_8$	$(\text{Co}_{75}\text{Fe}_{25})_{92}\text{Mn}_8$
		260	27.9						
		300	28.2					$(\text{Co}_{75}\text{Fe}_{25})_{91.2}\text{Mn}_{8.8}$	$(\text{Co}_{75}\text{Fe}_{25})_{87.9}\text{Mn}_{12.1}$
		350	18.1						
		400	14.5				$\text{Fe}_{91.65}\text{Pt}_{0.2}\text{Mn}_{8.15}$	$(\text{Co}_{75}\text{Fe}_{25})_{90.3}\text{Mn}_{9.7}$	$(\text{Co}_{75}\text{Fe}_{25})_{83.7}\text{Mn}_{16.3}$
107	c)	rt.	11.6	$(\text{Ni}_{80}\text{Fe}_{20})_{92}\text{Mn}_8$	$(\text{Ni}_{80}\text{Fe}_{20})_{92}\text{Mn}_8$	$\text{Fe}_{91.7}\text{Pt}_{0.3}\text{Mn}_8$	$\text{Fe}_{91.7}\text{Pt}_{0.3}\text{Mn}_8$	$(\text{Co}_{75}\text{Fe}_{25})_{92}\text{Mn}_8$	$(\text{Co}_{75}\text{Fe}_{25})_{92}\text{Mn}_8$
		260	25.9						
		300	28.1					$(\text{Co}_{75}\text{Fe}_{25})_{91.2}\text{Mn}_{8.8}$	$(\text{Co}_{75}\text{Fe}_{25})_{87.9}\text{Mn}_{12.1}$
		350	24.9						
		400	25.8				$\text{Fe}_{91.6}\text{Pt}_{0.3}\text{Mn}_{8.1}$	$(\text{Co}_{75}\text{Fe}_{25})_{90.3}\text{Mn}_{9.7}$	$(\text{Co}_{75}\text{Fe}_{25})_{83.7}\text{Mn}_{16.3}$
108	c)	rt.	12	$(\text{Ni}_{80}\text{Fe}_{20})_{92}\text{Mn}_8$	$(\text{Ni}_{80}\text{Fe}_{20})_{92}\text{Mn}_8$	$\text{Fe}_{90}\text{Pt}_2\text{Mn}_8$	$\text{Fe}_{90}\text{Pt}_2\text{Mn}_8$	$(\text{Co}_{75}\text{Fe}_{25})_{92}\text{Mn}_8$	$(\text{Co}_{75}\text{Fe}_{25})_{92}\text{Mn}_8$
		260	26.8						
		300	29.7					$(\text{Co}_{75}\text{Fe}_{25})_{91.2}\text{Mn}_{8.8}$	$(\text{Co}_{75}\text{Fe}_{25})_{87.9}\text{Mn}_{12.1}$
		350	28.7						
		400	30				$\text{Fe}_{89.95}\text{Pt}_2\text{Mn}_{8.05}$	$(\text{Co}_{75}\text{Fe}_{25})_{90.3}\text{Mn}_{9.7}$	$(\text{Co}_{75}\text{Fe}_{25})_{83.7}\text{Mn}_{16.3}$

[0068] continued

[Table 17] continued

TABLE 7b)-2

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
109	c)	r.t.	12.9	$(\text{Ni}_{80}\text{Fe}_{20})_{92}\text{Mn}_8$	$(\text{Ni}_{80}\text{Fe}_{20})_{92}\text{Mn}_8$	$\text{Fe}_{85}\text{Pt}_7\text{Mn}_8$	$\text{Fe}_{85}\text{Pt}_7\text{Mn}_8$	$(\text{Co}_{75}\text{Fe}_{25})_{92}\text{Mn}_8$	$(\text{Co}_{75}\text{Fe}_{25})_{92}\text{Mn}_8$
		260	26.2					$(\text{Co}_{75}\text{Fe}_{25})_{91.2}\text{Mn}_{8.8}$	$(\text{Co}_{75}\text{Fe}_{25})_{87.9}\text{Mn}_{12.1}$
		300	31.1						
		350	32.3						
		400	37.3					$(\text{Co}_{75}\text{Fe}_{25})_{90.3}\text{Mn}_{9.7}$	$(\text{Co}_{75}\text{Fe}_{25})_{83.7}\text{Mn}_{16.3}$
110	c)	r.t.	11	$(\text{Ni}_{80}\text{Fe}_{20})_{92}\text{Mn}_8$	$(\text{Ni}_{80}\text{Fe}_{20})_{92}\text{Mn}_8$	$\text{Fe}_{71}\text{Pt}_{21}\text{Mn}_8$	$\text{Fe}_{71}\text{Pt}_{21}\text{Mn}_8$	$(\text{Co}_{75}\text{Fe}_{25})_{92}\text{Mn}_8$	$(\text{Co}_{75}\text{Fe}_{25})_{92}\text{Mn}_8$
		260	24.9					$(\text{Co}_{75}\text{Fe}_{25})_{91.2}\text{Mn}_{8.8}$	$(\text{Co}_{75}\text{Fe}_{25})_{87.9}\text{Mn}_{12.1}$
		300	26.2						
		350	30.4						
		400	34.1					$(\text{Co}_{75}\text{Fe}_{25})_{90.3}\text{Mn}_{9.7}$	$(\text{Co}_{75}\text{Fe}_{25})_{83.7}\text{Mn}_{16.3}$
111	c)	r.t.	10.6	$(\text{Ni}_{80}\text{Fe}_{20})_{92}\text{Mn}_8$	$(\text{Ni}_{80}\text{Fe}_{20})_{92}\text{Mn}_8$	$\text{Fe}_{41}\text{Pt}_{51}\text{Mn}_8$	$\text{Fe}_{41}\text{Pt}_{51}\text{Mn}_8$	$(\text{Co}_{75}\text{Fe}_{25})_{92}\text{Mn}_8$	$(\text{Co}_{75}\text{Fe}_{25})_{92}\text{Mn}_8$
		260	24.9					$(\text{Co}_{75}\text{Fe}_{25})_{91.2}\text{Mn}_{8.8}$	$(\text{Co}_{75}\text{Fe}_{25})_{87.9}\text{Mn}_{12.1}$
		300	26.1						
		350	28.5						
		400	32.6					$(\text{Co}_{75}\text{Fe}_{25})_{90.3}\text{Mn}_{9.7}$	$(\text{Co}_{75}\text{Fe}_{25})_{83.7}\text{Mn}_{16.3}$
112	c)	r.t.	10.2	$(\text{Ni}_{80}\text{Fe}_{20})_{92}\text{Mn}_8$	$(\text{Ni}_{80}\text{Fe}_{20})_{92}\text{Mn}_8$	$\text{Fe}_{38}\text{Pt}_{64}\text{Mn}_8$	$\text{Fe}_{38}\text{Pt}_{64}\text{Mn}_8$	$(\text{Co}_{75}\text{Fe}_{25})_{92}\text{Mn}_8$	$(\text{Co}_{75}\text{Fe}_{25})_{92}\text{Mn}_8$
		260	19.7					$(\text{Co}_{75}\text{Fe}_{25})_{91.2}\text{Mn}_{8.8}$	$(\text{Co}_{75}\text{Fe}_{25})_{87.9}\text{Mn}_{12.1}$
		300	21.9						
		350	18.3						
		400	15.4					$(\text{Co}_{75}\text{Fe}_{25})_{90.3}\text{Mn}_{9.7}$	$(\text{Co}_{75}\text{Fe}_{25})_{83.7}\text{Mn}_{16.3}$

[0069]

[Table 18]

TABLE 7d-1

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
113	c)	r.t.	11.6	$(\text{Ni}_{80}\text{Fe}_{20})_{88}\text{Mn}_{12}$	$(\text{Ni}_{80}\text{Fe}_{20})_{88}\text{Mn}_{12}$	$\text{Fe}_{88}\text{Mn}_{12}$	$\text{Fe}_{88}\text{Mn}_{12}$	$(\text{Co}_{75}\text{Fe}_{25})_{88}\text{Mn}_{12}$	$(\text{Co}_{75}\text{Fe}_{25})_{88}\text{Mn}_{12}$
		260	26.1						
		300	26.5						
		350	17					$(\text{Co}_{75}\text{Fe}_{25})_{87.3}\text{Mn}_{12.7}$	$(\text{Co}_{75}\text{Fe}_{25})_{84.5}\text{Mn}_{15.5}$
		400	13.6				$\text{Fe}_{87.9}\text{Mn}_{12.1}$	$(\text{Co}_{75}\text{Fe}_{25})_{86.6}\text{Mn}_{13.4}$	$(\text{Co}_{75}\text{Fe}_{25})_{81}\text{Mn}_{19}$
114	c)	r.t.	11.8	$(\text{Ni}_{80}\text{Fe}_{20})_{88}\text{Mn}_{12}$	$(\text{Ni}_{80}\text{Fe}_{20})_{88}\text{Mn}_{12}$	$\text{Fe}_{87.8}\text{Pt}_{0.2}\text{Mn}_{12}$	$\text{Fe}_{87.8}\text{Pt}_{0.2}\text{Mn}_{12}$	$(\text{Co}_{75}\text{Fe}_{25})_{88}\text{Mn}_{12}$	$(\text{Co}_{75}\text{Fe}_{25})_{88}\text{Mn}_{12}$
		260	26.5						
		300	26.9						
		350	17.2					$(\text{Co}_{75}\text{Fe}_{25})_{87.3}\text{Mn}_{12.7}$	$(\text{Co}_{75}\text{Fe}_{25})_{84.5}\text{Mn}_{15.5}$
		400	13.7				$\text{Fe}_{87.7}\text{Pt}_{0.2}\text{Mn}_{12.1}$	$(\text{Co}_{75}\text{Fe}_{25})_{86.6}\text{Mn}_{13.4}$	$(\text{Co}_{75}\text{Fe}_{25})_{81}\text{Mn}_{19}$
115	c)	r.t.	11.5	$(\text{Ni}_{80}\text{Fe}_{20})_{88}\text{Mn}_{12}$	$(\text{Ni}_{80}\text{Fe}_{20})_{88}\text{Mn}_{12}$	$\text{Fe}_{87.7}\text{Pt}_{0.3}\text{Mn}_{12}$	$\text{Fe}_{87.7}\text{Pt}_{0.3}\text{Mn}_{12}$	$(\text{Co}_{75}\text{Fe}_{25})_{88}\text{Mn}_{12}$	$(\text{Co}_{75}\text{Fe}_{25})_{88}\text{Mn}_{12}$
		260	25.7						
		300	27.8						
		350	23.5					$(\text{Co}_{75}\text{Fe}_{25})_{87.3}\text{Mn}_{12.7}$	$(\text{Co}_{75}\text{Fe}_{25})_{84.5}\text{Mn}_{15.5}$
		400	24				$\text{Fe}_{87.65}\text{Pt}_{0.3}\text{Mn}_{12.05}$	$(\text{Co}_{75}\text{Fe}_{25})_{86.6}\text{Mn}_{13.4}$	$(\text{Co}_{75}\text{Fe}_{25})_{81}\text{Mn}_{19}$
116	c)	r.t.	11.8	$(\text{Ni}_{80}\text{Fe}_{20})_{88}\text{Mn}_{12}$	$(\text{Ni}_{80}\text{Fe}_{20})_{88}\text{Mn}_{12}$	$\text{Fe}_{86}\text{Pt}_2\text{Mn}_{12}$	$\text{Fe}_{86}\text{Pt}_2\text{Mn}_{12}$	$(\text{Co}_{75}\text{Fe}_{25})_{88}\text{Mn}_{12}$	$(\text{Co}_{75}\text{Fe}_{25})_{88}\text{Mn}_{12}$
		260	26.6						
		300	27.9						
		350	25.7					$(\text{Co}_{75}\text{Fe}_{25})_{87.3}\text{Mn}_{12.7}$	$(\text{Co}_{75}\text{Fe}_{25})_{84.5}\text{Mn}_{15.5}$
		400	27.2					$(\text{Co}_{75}\text{Fe}_{25})_{86.6}\text{Mn}_{13.4}$	$(\text{Co}_{75}\text{Fe}_{25})_{81}\text{Mn}_{19}$

[0069] continued

[Table 18] continued

TABLE 7c)-2

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
117	c)	rt.	11.9	$(\text{Ni}_{80}\text{Fe}_{20})_{88}\text{Mn}_{12}$	$(\text{Ni}_{80}\text{Fe}_{20})_{88}\text{Mn}_{12}$	$\text{Fe}_{81}\text{Pt}_7\text{Mn}_{12}$	$\text{Fe}_{81}\text{Pt}_7\text{Mn}_{12}$	$(\text{Co}_{75}\text{Fe}_{25})_{88}\text{Mn}_{12}$	$(\text{Co}_{75}\text{Fe}_{25})_{88}\text{Mn}_{12}$
		260	25.9						
		300	30.2						
		350	27.2					$(\text{Co}_{75}\text{Fe}_{25})_{87.3}\text{Mn}_{12.7}$	$(\text{Co}_{75}\text{Fe}_{25})_{84.5}\text{Mn}_{15.5}$
		400	29.9					$(\text{Co}_{75}\text{Fe}_{25})_{86.6}\text{Mn}_{13.4}$	$(\text{Co}_{75}\text{Fe}_{25})_{81}\text{Mn}_{19}$
118	c)	rt.	10.1	$(\text{Ni}_{80}\text{Fe}_{20})_{88}\text{Mn}_{12}$	$(\text{Ni}_{80}\text{Fe}_{20})_{88}\text{Mn}_{12}$	$\text{Fe}_{71}\text{Pt}_{17}\text{Mn}_{12}$	$\text{Fe}_{71}\text{Pt}_{17}\text{Mn}_{12}$	$(\text{Co}_{75}\text{Fe}_{25})_{88}\text{Mn}_{12}$	$(\text{Co}_{75}\text{Fe}_{25})_{88}\text{Mn}_{12}$
		260	23.9						
		300	25.7						
		350	26.8					$(\text{Co}_{75}\text{Fe}_{25})_{87.3}\text{Mn}_{12.7}$	$(\text{Co}_{75}\text{Fe}_{25})_{84.5}\text{Mn}_{15.5}$
		400	29.4					$(\text{Co}_{75}\text{Fe}_{25})_{86.6}\text{Mn}_{13.4}$	$(\text{Co}_{75}\text{Fe}_{25})_{81}\text{Mn}_{19}$
119	c)	rt.	10.1	$(\text{Ni}_{80}\text{Fe}_{20})_{88}\text{Mn}_{12}$	$(\text{Ni}_{80}\text{Fe}_{20})_{88}\text{Mn}_{12}$	$\text{Fe}_{41}\text{Pt}_{47}\text{Mn}_{12}$	$\text{Fe}_{41}\text{Pt}_{47}\text{Mn}_{12}$	$(\text{Co}_{75}\text{Fe}_{25})_{88}\text{Mn}_{12}$	$(\text{Co}_{75}\text{Fe}_{25})_{88}\text{Mn}_{12}$
		260	24.2						
		300	25.6						
		350	24.9					$(\text{Co}_{75}\text{Fe}_{25})_{87.3}\text{Mn}_{12.7}$	$(\text{Co}_{75}\text{Fe}_{25})_{84.5}\text{Mn}_{15.5}$
		400	27.2					$(\text{Co}_{75}\text{Fe}_{25})_{86.6}\text{Mn}_{13.4}$	$(\text{Co}_{75}\text{Fe}_{25})_{81}\text{Mn}_{19}$
120	c)	rt.	9.9	$(\text{Ni}_{80}\text{Fe}_{20})_{88}\text{Mn}_{12}$	$(\text{Ni}_{80}\text{Fe}_{20})_{88}\text{Mn}_{12}$	$\text{Fe}_{38}\text{Pt}_{60}\text{Mn}_{12}$	$\text{Fe}_{38}\text{Pt}_{60}\text{Mn}_{12}$	$(\text{Co}_{75}\text{Fe}_{25})_{88}\text{Mn}_{12}$	$(\text{Co}_{75}\text{Fe}_{25})_{88}\text{Mn}_{12}$
		260	19.2						
		300	21.2						
		350	17					$(\text{Co}_{75}\text{Fe}_{25})_{87.3}\text{Mn}_{12.7}$	$(\text{Co}_{75}\text{Fe}_{25})_{84.5}\text{Mn}_{15.5}$
		400	13.9					$(\text{Co}_{75}\text{Fe}_{25})_{86.6}\text{Mn}_{13.4}$	$(\text{Co}_{75}\text{Fe}_{25})_{81}\text{Mn}_{19}$

[0070]

[Table 19]

TABLE 7d)-1

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
121	c)	r.t.	10.9	$(\text{Ni}_{80}\text{Fe}_{20})_{81}\text{Mn}_{19}$	$(\text{Ni}_{80}\text{Fe}_{20})_{81}\text{Mn}_{19}$	$\text{Fe}_{81}\text{Mn}_{19}$	$\text{Fe}_{81}\text{Mn}_{19}$	$(\text{Co}_{75}\text{Fe}_{25})_{81}\text{Mn}_{19}$	$(\text{Co}_{75}\text{Fe}_{25})_{81}\text{Mn}_{19}$
		260	24.2						
		300	24.7						
		350	16.1					$(\text{Co}_{75}\text{Fe}_{25})_{80.5}\text{Mn}_{19.5}$	$(\text{Co}_{75}\text{Fe}_{25})_{78.6}\text{Mn}_{21.4}$
		400	12.8				$\text{Fe}_{80.95}\text{Mn}_{19.05}$	$(\text{Co}_{75}\text{Fe}_{25})_{80}\text{Mn}_{20}$	$(\text{Co}_{75}\text{Fe}_{25})_{75.1}\text{Mn}_{23.9}$
122	c)	r.t.	11.2	$(\text{Ni}_{80}\text{Fe}_{20})_{81}\text{Mn}_{19}$	$(\text{Ni}_{80}\text{Fe}_{20})_{81}\text{Mn}_{19}$	$\text{Fe}_{80.8}\text{Pt}_{0.2}\text{Mn}_{19}$	$\text{Fe}_{80.8}\text{Pt}_{0.2}\text{Mn}_{19}$	$(\text{Co}_{75}\text{Fe}_{25})_{81}\text{Mn}_{19}$	$(\text{Co}_{75}\text{Fe}_{25})_{81}\text{Mn}_{19}$
		260	25.1						
		300	25.3						
		350	16.1					$(\text{Co}_{75}\text{Fe}_{25})_{80.5}\text{Mn}_{19.5}$	$(\text{Co}_{75}\text{Fe}_{25})_{78.6}\text{Mn}_{21.4}$
		400	12.8				$\text{Fe}_{80.75}\text{Pt}_{0.2}\text{Mn}_{19.05}$	$(\text{Co}_{75}\text{Fe}_{25})_{80}\text{Mn}_{20}$	$(\text{Co}_{75}\text{Fe}_{25})_{75.1}\text{Mn}_{23.9}$
123	c)	r.t.	11.4	$(\text{Ni}_{80}\text{Fe}_{20})_{81}\text{Mn}_{19}$	$(\text{Ni}_{80}\text{Fe}_{20})_{81}\text{Mn}_{19}$	$\text{Fe}_{80.7}\text{Pt}_{0.3}\text{Mn}_{19}$	$\text{Fe}_{80.7}\text{Pt}_{0.3}\text{Mn}_{19}$	$(\text{Co}_{75}\text{Fe}_{25})_{81}\text{Mn}_{19}$	$(\text{Co}_{75}\text{Fe}_{25})_{81}\text{Mn}_{19}$
		260	25.5						
		300	26.9						
		350	21.8					$(\text{Co}_{75}\text{Fe}_{25})_{80.5}\text{Mn}_{19.5}$	$(\text{Co}_{75}\text{Fe}_{25})_{78.6}\text{Mn}_{21.4}$
		400	21.9					$(\text{Co}_{75}\text{Fe}_{25})_{80}\text{Mn}_{20}$	$(\text{Co}_{75}\text{Fe}_{25})_{75.1}\text{Mn}_{23.9}$
124	c)	r.t.	11.4	$(\text{Ni}_{80}\text{Fe}_{20})_{81}\text{Mn}_{19}$	$(\text{Ni}_{80}\text{Fe}_{20})_{81}\text{Mn}_{19}$	$\text{Fe}_{79}\text{Pt}_2\text{Mn}_{19}$	$\text{Fe}_{79}\text{Pt}_2\text{Mn}_{19}$	$(\text{Co}_{75}\text{Fe}_{25})_{81}\text{Mn}_{19}$	$(\text{Co}_{75}\text{Fe}_{25})_{81}\text{Mn}_{19}$
		260	26.1						
		300	27.2						
		350	22.7					$(\text{Co}_{75}\text{Fe}_{25})_{80.5}\text{Mn}_{19.5}$	$(\text{Co}_{75}\text{Fe}_{25})_{78.6}\text{Mn}_{21.4}$
		400	23.1					$(\text{Co}_{75}\text{Fe}_{25})_{80}\text{Mn}_{20}$	$(\text{Co}_{75}\text{Fe}_{25})_{75.1}\text{Mn}_{23.9}$

[0070] continued

[Table 19] continued

TABLE 7d)-2

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
125	c)	r.t.	11.6	$(\text{Ni}_{80}\text{Fe}_{20})_{81}\text{Mn}_{19}$	$(\text{Ni}_{80}\text{Fe}_{20})_{81}\text{Mn}_{19}$	$\text{Fe}_{74}\text{Pt}_7\text{Mn}_{19}$	$\text{Fe}_{74}\text{Pt}_7\text{Mn}_{19}$	$(\text{Co}_{75}\text{Fe}_{25})_{81}\text{Mn}_{19}$	$(\text{Co}_{75}\text{Fe}_{25})_{81}\text{Mn}_{19}$
		260	25.8					$(\text{Co}_{75}\text{Fe}_{25})_{80.5}\text{Mn}_{19.5}$	$(\text{Co}_{75}\text{Fe}_{25})_{78.6}\text{Mn}_{21.4}$
		300	28.9						
		350	24.4						
		400	25.1					$(\text{Co}_{75}\text{Fe}_{25})_{80}\text{Mn}_{20}$	$(\text{Co}_{75}\text{Fe}_{25})_{75.1}\text{Mn}_{23.9}$
126	c)	r.t.	9.9	$(\text{Ni}_{80}\text{Fe}_{20})_{81}\text{Mn}_{19}$	$(\text{Ni}_{80}\text{Fe}_{20})_{81}\text{Mn}_{19}$	$\text{Fe}_{71}\text{Pt}_{10}\text{Mn}_{19}$	$\text{Fe}_{71}\text{Pt}_{10}\text{Mn}_{19}$	$(\text{Co}_{75}\text{Fe}_{25})_{81}\text{Mn}_{19}$	$(\text{Co}_{75}\text{Fe}_{25})_{81}\text{Mn}_{19}$
		260	22.1					$(\text{Co}_{75}\text{Fe}_{25})_{80.5}\text{Mn}_{19.5}$	$(\text{Co}_{75}\text{Fe}_{25})_{78.6}\text{Mn}_{21.4}$
		300	24.2						
		350	23.1						
		400	24					$(\text{Co}_{75}\text{Fe}_{25})_{80}\text{Mn}_{20}$	$(\text{Co}_{75}\text{Fe}_{25})_{75.1}\text{Mn}_{23.9}$
127	c)	r.t.	9.8	$(\text{Ni}_{80}\text{Fe}_{20})_{81}\text{Mn}_{19}$	$(\text{Ni}_{80}\text{Fe}_{20})_{81}\text{Mn}_{19}$	$\text{Fe}_{41}\text{Pt}_{40}\text{Mn}_{19}$	$\text{Fe}_{41}\text{Pt}_{40}\text{Mn}_{19}$	$(\text{Co}_{75}\text{Fe}_{25})_{81}\text{Mn}_{19}$	$(\text{Co}_{75}\text{Fe}_{25})_{81}\text{Mn}_{19}$
		260	23.9					$(\text{Co}_{75}\text{Fe}_{25})_{80.5}\text{Mn}_{19.5}$	$(\text{Co}_{75}\text{Fe}_{25})_{78.6}\text{Mn}_{21.4}$
		300	24.2						
		350	21.4						
		400	21.9					$(\text{Co}_{75}\text{Fe}_{25})_{80}\text{Mn}_{20}$	$(\text{Co}_{75}\text{Fe}_{25})_{75.1}\text{Mn}_{23.9}$
128	c)	r.t.	9.5	$(\text{Ni}_{80}\text{Fe}_{20})_{81}\text{Mn}_{19}$	$(\text{Ni}_{80}\text{Fe}_{20})_{81}\text{Mn}_{19}$	$\text{Fe}_{38}\text{Pt}_{43}\text{Mn}_{19}$	$\text{Fe}_{38}\text{Pt}_{43}\text{Mn}_{19}$	$(\text{Co}_{75}\text{Fe}_{25})_{81}\text{Mn}_{19}$	$(\text{Co}_{75}\text{Fe}_{25})_{81}\text{Mn}_{19}$
		260	18.2					$(\text{Co}_{75}\text{Fe}_{25})_{80.5}\text{Mn}_{19.5}$	$(\text{Co}_{75}\text{Fe}_{25})_{78.6}\text{Mn}_{21.4}$
		300	20.1						
		350	15.1						
		400	12.7					$(\text{Co}_{75}\text{Fe}_{25})_{80}\text{Mn}_{20}$	$(\text{Co}_{75}\text{Fe}_{25})_{75.1}\text{Mn}_{23.9}$

[0071]

[Table 20]

TABLE 8a)-1

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
129	c)	r.t.	10.1	$(\text{Ni}_{80}\text{Fe}_{20})_{78}\text{Mn}_{22}$	$(\text{Ni}_{80}\text{Fe}_{20})_{78}\text{Mn}_{22}$	$\text{Fe}_{78}\text{Mn}_{22}$	$\text{Fe}_{78}\text{Mn}_{22}$	$(\text{Co}_{75}\text{Fe}_{25})_{78}\text{Mn}_{22}$	$(\text{Co}_{75}\text{Fe}_{25})_{78}\text{Mn}_{22}$
		260	21.1					$(\text{Co}_{75}\text{Fe}_{25})_{77.7}\text{Mn}_{22.3}$	$(\text{Co}_{75}\text{Fe}_{25})_{76.4}\text{Mn}_{23.6}$
		300	21.4						
		350	13.2						
		400	10.6					$(\text{Co}_{75}\text{Fe}_{25})_{77.4}\text{Mn}_{22.6}$	$(\text{Co}_{75}\text{Fe}_{25})_{74.9}\text{Mn}_{25.1}$
130	c)	r.t.	10.2	$(\text{Ni}_{80}\text{Fe}_{20})_{78}\text{Mn}_{22}$	$(\text{Ni}_{80}\text{Fe}_{20})_{78}\text{Mn}_{22}$	$\text{Fe}_{77.8}\text{Pt}_{0.2}\text{Mn}_{22}$	$\text{Fe}_{77.8}\text{Pt}_{0.2}\text{Mn}_{22}$	$(\text{Co}_{75}\text{Fe}_{25})_{78}\text{Mn}_{22}$	$(\text{Co}_{75}\text{Fe}_{25})_{78}\text{Mn}_{22}$
		260	21.4					$(\text{Co}_{75}\text{Fe}_{25})_{77.7}\text{Mn}_{22.3}$	$(\text{Co}_{75}\text{Fe}_{25})_{76.4}\text{Mn}_{23.6}$
		300	21.6						
		350	13						
		400	10.4					$(\text{Co}_{75}\text{Fe}_{25})_{77.4}\text{Mn}_{22.6}$	$(\text{Co}_{75}\text{Fe}_{25})_{74.9}\text{Mn}_{25.1}$
131	c)	r.t.	10.4	$(\text{Ni}_{80}\text{Fe}_{20})_{78}\text{Mn}_{22}$	$(\text{Ni}_{80}\text{Fe}_{20})_{78}\text{Mn}_{22}$	$\text{Fe}_{77.7}\text{Pt}_{0.3}\text{Mn}_{22}$	$\text{Fe}_{77.7}\text{Pt}_{0.3}\text{Mn}_{22}$	$(\text{Co}_{75}\text{Fe}_{25})_{78}\text{Mn}_{22}$	$(\text{Co}_{75}\text{Fe}_{25})_{78}\text{Mn}_{22}$
		260	21.6					$(\text{Co}_{75}\text{Fe}_{25})_{77.7}\text{Mn}_{22.3}$	$(\text{Co}_{75}\text{Fe}_{25})_{76.4}\text{Mn}_{23.6}$
		300	21.7						
		350	14.6						
		400	12.2					$(\text{Co}_{75}\text{Fe}_{25})_{77.4}\text{Mn}_{22.6}$	$(\text{Co}_{75}\text{Fe}_{25})_{74.9}\text{Mn}_{25.1}$
132	c)	r.t.	10.5	$(\text{Ni}_{80}\text{Fe}_{20})_{78}\text{Mn}_{22}$	$(\text{Ni}_{80}\text{Fe}_{20})_{78}\text{Mn}_{22}$	$\text{Fe}_{76}\text{Pt}_2\text{Mn}_{22}$	$\text{Fe}_{76}\text{Pt}_2\text{Mn}_{22}$	$(\text{Co}_{75}\text{Fe}_{25})_{78}\text{Mn}_{22}$	$(\text{Co}_{75}\text{Fe}_{25})_{78}\text{Mn}_{22}$
		260	21.9					$(\text{Co}_{75}\text{Fe}_{25})_{77.7}\text{Mn}_{22.3}$	$(\text{Co}_{75}\text{Fe}_{25})_{76.4}\text{Mn}_{23.6}$
		300	21.7						
		350	14.7						
		400	12.5					$(\text{Co}_{75}\text{Fe}_{25})_{77.4}\text{Mn}_{22.6}$	$(\text{Co}_{75}\text{Fe}_{25})_{74.9}\text{Mn}_{25.1}$

[0071] continued

[Table 20] continued

TABLE 8a)-2

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 6
133	c)	r.t.	10.7	$(\text{Ni}_{80}\text{Fe}_{20})_{78}\text{Mn}_{22}$	$(\text{Ni}_{80}\text{Fe}_{20})_{78}\text{Mn}_{22}$	$\text{Fe}_{71}\text{Pt}_7\text{Mn}_{22}$	$\text{Fe}_{71}\text{Pt}_7\text{Mn}_{22}$	$(\text{Co}_{75}\text{Fe}_{25})_{78}\text{Mn}_{22}$	$(\text{Co}_{75}\text{Fe}_{25})_{78}\text{Mn}_{22}$
		260	22.1					$(\text{Co}_{75}\text{Fe}_{25})_{77.7}\text{Mn}_{22.3}$	$(\text{Co}_{75}\text{Fe}_{25})_{76.4}\text{Mn}_{23.6}$
		300	22.3						
		350	14.9						
		400	12.8					$(\text{Co}_{75}\text{Fe}_{25})_{77.4}\text{Mn}_{22.6}$	$(\text{Co}_{75}\text{Fe}_{25})_{74.9}\text{Mn}_{25.1}$
134	c)	r.t.	9.6	$(\text{Ni}_{80}\text{Fe}_{20})_{78}\text{Mn}_{22}$	$(\text{Ni}_{80}\text{Fe}_{20})_{78}\text{Mn}_{22}$	$\text{Fe}_{68}\text{Pt}_{10}\text{Mn}_{22}$	$\text{Fe}_{68}\text{Pt}_{10}\text{Mn}_{22}$	$(\text{Co}_{75}\text{Fe}_{25})_{78}\text{Mn}_{22}$	$(\text{Co}_{75}\text{Fe}_{25})_{78}\text{Mn}_{22}$
		260	18.2					$(\text{Co}_{75}\text{Fe}_{25})_{77.7}\text{Mn}_{22.3}$	$(\text{Co}_{75}\text{Fe}_{25})_{76.4}\text{Mn}_{23.6}$
		300	19.9						
		350	14.6						
		400	12.7					$(\text{Co}_{75}\text{Fe}_{25})_{77.4}\text{Mn}_{22.6}$	$(\text{Co}_{75}\text{Fe}_{25})_{74.9}\text{Mn}_{25.1}$
135	c)	r.t.	9.5	$(\text{Ni}_{80}\text{Fe}_{20})_{78}\text{Mn}_{22}$	$(\text{Ni}_{80}\text{Fe}_{20})_{78}\text{Mn}_{22}$	$\text{Fe}_{41}\text{Pt}_{37}\text{Mn}_{22}$	$\text{Fe}_{41}\text{Pt}_{37}\text{Mn}_{22}$	$(\text{Co}_{75}\text{Fe}_{25})_{78}\text{Mn}_{22}$	$(\text{Co}_{75}\text{Fe}_{25})_{78}\text{Mn}_{22}$
		260	17.6					$(\text{Co}_{75}\text{Fe}_{25})_{77.7}\text{Mn}_{22.3}$	$(\text{Co}_{75}\text{Fe}_{25})_{76.4}\text{Mn}_{23.6}$
		300	18.1						
		350	13.4						
		400	10.4					$(\text{Co}_{75}\text{Fe}_{25})_{77.4}\text{Mn}_{22.6}$	$(\text{Co}_{75}\text{Fe}_{25})_{74.9}\text{Mn}_{25.1}$
136	c)	r.t.	8.1	$(\text{Ni}_{80}\text{Fe}_{20})_{78}\text{Mn}_{22}$	$(\text{Ni}_{80}\text{Fe}_{20})_{78}\text{Mn}_{22}$	$\text{Fe}_{38}\text{Pt}_{40}\text{Mn}_{22}$	$\text{Fe}_{38}\text{Pt}_{40}\text{Mn}_{22}$	$(\text{Co}_{75}\text{Fe}_{25})_{78}\text{Mn}_{22}$	$(\text{Co}_{75}\text{Fe}_{25})_{78}\text{Mn}_{22}$
		260	16.2					$(\text{Co}_{75}\text{Fe}_{25})_{77.7}\text{Mn}_{22.3}$	$(\text{Co}_{75}\text{Fe}_{25})_{76.4}\text{Mn}_{23.6}$
		300	16.9						
		350	11.3						
		400	10.7					$(\text{Co}_{75}\text{Fe}_{25})_{77.4}\text{Mn}_{22.6}$	$(\text{Co}_{75}\text{Fe}_{25})_{74.9}\text{Mn}_{25.1}$

[0072]

[Table 21]

TABLE 8b)-1

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3
137	d)	r.t.	18.9	Co ₅₀ Pt ₅₀	Co ₅₀ Pt ₅₀	Co ₇₅ Fe ₂₅
		260	37.1			
		300	36.5			
		350	15.1			
		400	9.9			
138	d)	r.t.	18.8	Co ₅₀ Pt ₅₀	Co ₅₀ Pt ₅₀	(Co ₇₅ Fe ₂₅) _{99.8} Rh _{0.2}
		260	35.6			
		300	36.6			
		350	15.4			
		400	10.5			
139	d)	r.t.	18.5	Co ₅₀ Pt ₅₀	Co ₅₀ Pt ₅₀	(Co ₇₅ Fe ₂₅) _{99.7} Rh _{0.3}
		260	35.9			
		300	36.6			
		350	26.5			
		400	25.9			
140	d)	r.t.	18.1	Co ₅₀ Pt ₅₀	Co ₅₀ Pt ₅₀	(Co ₇₅ Fe ₂₅) ₉₇ Rh ₃
		260	36.2			
		300	36.4			
		350	35.6			
		400	30.1			

[0072] continued

[Table 21] continued

TABLE 8b)-2

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 4	Composition 5	Composition 6	Composition 7	Composition 8	Composition 9
137	d)	r.t.	18.9	Co ₇₅ Fe ₂₅	Ni ₈₀ Fe ₂₀	Co ₇₅ Fe ₂₅	Co ₇₅ Fe ₂₅	Co ₅₀ Pt ₅₀	Co ₅₀ Pt ₅₀
		260	37.1						
		300	36.5						
		350	15.1						
		400	9.9						
138	d)	r.t.	18.8	(Co ₇₅ Fe ₂₅) _{99.8} Rh _{0.2}	Ni ₈₀ Fe ₂₀	(Co ₇₅ Fe ₂₅) _{99.8} Rh _{0.2}	(Co ₇₅ Fe ₂₅) _{99.8} Rh _{0.2}	Co ₅₀ Pt ₅₀	Co ₅₀ Pt ₅₀
		260	35.6						
		300	36.6						
		350	15.4						
		400	10.5						
139	d)	r.t.	18.5	(Co ₇₅ Fe ₂₅) _{99.7} Rh _{0.3}	Ni ₈₀ Fe ₂₀	(Co ₇₅ Fe ₂₅) _{99.7} Rh _{0.3}	(Co ₇₅ Fe ₂₅) _{99.7} Rh _{0.3}	Co ₅₀ Pt ₅₀	Co ₅₀ Pt ₅₀
		260	35.9						
		300	36.6						
		350	26.5						
		400	25.9						
140	d)	r.t.	18.1	(Co ₇₅ Fe ₂₅) ₉₇ Rh ₃	Ni ₈₀ Fe ₂₀	(Co ₇₅ Fe ₂₅) ₉₇ Rh ₃	(Co ₇₅ Fe ₂₅) ₉₇ Rh ₃	Co ₅₀ Pt ₅₀	Co ₅₀ Pt ₅₀
		260	36.2						
		300	36.4						
		350	35.6						
		400	30.1						

[0072] continued

[Table 21] continued

TABLE 8b)-3

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3
141	d)	r.t.	16.5	Co ₅₀ Pt ₅₀	Co ₅₀ Pt ₅₀	(Co ₇₅ Fe ₂₅) ₈₅ Rh ₁₅
		260	32.1			
		300	33.2			
		350	34.2			
		400	36.6			
142	d)	r.t.	16.1	Co ₅₀ Pt ₅₀	Co ₅₀ Pt ₅₀	(Co ₇₅ Fe ₂₅) ₇₁ Rh ₂₉
		260	30.1			
		300	32.4			
		350	34.5			
		400	34.3			
143	d)	r.t.	15.2	Co ₅₀ Pt ₅₀	Co ₅₀ Pt ₅₀	(Co ₇₅ Fe ₂₅) ₄₁ Rh ₅₉
		260	25.7			
		300	26.6			
		350	30.3			
		400	29.8			
144	d)	r.t.	10.3	Co ₅₀ Pt ₅₀	Co ₅₀ Pt ₅₀	(Co ₇₅ Fe ₂₅) ₃₈ Rh ₆₂
		260	22.1			
		300	23.5			
		350	16.1			
		400	11.2			

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 4	Composition 5	Composition 6	Composition 7	Composition 8	Composition 9
141	d)	r.t.	16.5	(Co ₇₅ Fe ₂₅) ₈₅ Rh ₁₅	Ni ₈₀ Fe ₂₀	(Co ₇₅ Fe ₂₅) ₈₅ Rh ₁₅	(Co ₇₅ Fe ₂₅) ₈₅ Rh ₁₅	Co ₅₀ Pt ₅₀	Co ₅₀ Pt ₅₀
		260	32.1						
		300	33.2						
		350	34.2						
		400	36.6						
142	d)	r.t.	16.1	(Co ₇₅ Fe ₂₅) ₇₁ Rh ₂₉	Ni ₈₀ Fe ₂₀	(Co ₇₅ Fe ₂₅) ₇₁ Rh ₂₉	(Co ₇₅ Fe ₂₅) ₇₁ Rh ₂₉	Co ₅₀ Pt ₅₀	Co ₅₀ Pt ₅₀
		260	30.1						
		300	32.4						
		350	34.5						
		400	34.3						
143	d)	r.t.	15.2	(Co ₇₅ Fe ₂₅) ₄₁ Rh ₅₉	Ni ₈₀ Fe ₂₀	(Co ₇₅ Fe ₂₅) ₄₁ Rh ₅₉	(Co ₇₅ Fe ₂₅) ₄₁ Rh ₅₉	Co ₅₀ Pt ₅₀	Co ₅₀ Pt ₅₀
		260	25.7						
		300	26.6						
		350	30.3						
		400	29.8						
144	d)	r.t.	10.3	(Co ₇₅ Fe ₂₅) ₃₈ Rh ₆₂	Ni ₈₀ Fe ₂₀	(Co ₇₅ Fe ₂₅) ₃₈ Rh ₆₂	(Co ₇₅ Fe ₂₅) ₃₈ Rh ₆₂	Co ₅₀ Pt ₅₀	Co ₅₀ Pt ₅₀
		260	22.1						
		300	23.5						
		350	16.1						
		400	11.2						

[0073]

[Table 22]

TABLE 8c)-1

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3
145	d)	rt.	15.1	$\text{Co}_{50}\text{Fe}_{50}$	$\text{Co}_{50}\text{Fe}_{50}$	$\text{Co}_{90}\text{Fe}_{10}$
		260	32.1			
		300	34.1			
		350	10.1			
		400	8.5			
146	d)	rt.	15.3	$(\text{Co}_{50}\text{Fe}_{50})_{99.8}\text{Pt}_{0.2}$	$(\text{Co}_{50}\text{Fe}_{50})_{99.8}\text{Pt}_{0.2}$	$(\text{Co}_{50}\text{Fe}_{50})_{99.9}\text{Pt}_{0.1}$
		260	32.4			$(\text{Co}_{90}\text{Fe}_{10})_{99.8}\text{Pt}_{0.1}\text{Mn}_{0.1}$
		300	34.3			
		350	11.1			
		400	9.5			$(\text{Co}_{90}\text{Fe}_{10})_{99.7}\text{Pt}_{0.2}\text{Mn}_{0.1}$
147	d)	rt.	15.5	$(\text{Co}_{50}\text{Fe}_{50})_{99.7}\text{Pt}_{0.3}$	$(\text{Co}_{50}\text{Fe}_{50})_{99.7}\text{Pt}_{0.3}$	$(\text{Co}_{90}\text{Fe}_{10})_{99.85}\text{Mn}_{0.15}$
		260	33.1			$(\text{Co}_{90}\text{Fe}_{10})_{99.7}\text{Pt}_{0.15}\text{Mn}_{0.15}$
		300	35.2			
		350	28.4			
		400	24.6			$(\text{Co}_{90}\text{Fe}_{10})_{99.55}\text{Pt}_{0.3}\text{Mn}_{0.15}$
148	d)	rt.	16.3	$(\text{Co}_{50}\text{Fe}_{50})_{97}\text{Pt}_3$	$(\text{Co}_{50}\text{Fe}_{50})_{97}\text{Pt}_3$	$(\text{Co}_{90}\text{Fe}_{10})_{99}\text{Mn}_1$
		260	35.2			$(\text{Co}_{90}\text{Fe}_{10})_{98}\text{Pt}_1\text{Mn}_1$
		300	36.7			
		350	32.8			
		400	29.9			$(\text{Co}_{90}\text{Fe}_{10})_{97}\text{Pt}_2\text{Mn}_1$

[0073] continued

[Table 22] continued

TABLE 8c)-2

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 4	Composition 5	Composition 6	Composition 7	Composition 8	Composition 9
145	d)	r.t.	15.1	Fe ₆₀ Ni ₄₀	Ni ₈₀ Fe ₂₀	Fe ₆₀ Ni ₄₀	Co ₉₀ Fe ₁₀	Co ₅₀ Fe ₅₀	Co ₅₀ Fe ₅₀
		260	32.1						
		300	34.1						
		350	10.1	Fe ₅₇ Ni ₄₃	Ni _{78.9} Fe _{21.1}	Fe ₅₇ Ni ₄₃			
		400	8.5	Fe ₅₄ Ni ₄₆	Ni _{77.8} Fe _{22.2}	Fe ₅₄ Ni ₄₆			
146	d)	r.t.	15.3	(Fe ₆₀ Ni ₄₀) _{99.8} Ir _{0.2}	Ni ₈₀ Fe ₂₀	(Fe ₆₀ Ni ₄₀) _{99.8} Ir _{0.2}	(Co ₉₀ Fe ₁₀) _{99.8} Mn _{0.1}	(Co ₅₀ Fe ₅₀) _{99.8} Pt _{0.2}	(Co ₅₀ Fe ₅₀) _{99.8} Pt _{0.2}
		260	32.4						
		300	34.3						
		350	11.1	(Fe ₅₇ Ni ₄₃) _{99.8} Ir _{0.2}	Ni _{78.9} Fe _{21.1}	(Fe ₅₇ Ni ₄₃) _{99.8} Ir _{0.2}	(Co ₉₀ Fe ₁₀) _{99.8} Pt _{0.1} Mn _{0.1}		
		400	9.5	(Fe ₅₄ Ni ₄₆) _{99.8} Ir _{0.2}	Ni _{77.8} Fe _{22.2}	(Fe ₅₄ Ni ₄₆) _{99.8} Ir _{0.2}	(Co ₉₀ Fe ₁₀) _{99.7} Pt _{0.2} Mn _{0.1}		
147	d)	r.t.	15.5	(Fe ₆₀ Ni ₄₀) _{99.7} Ir _{0.3}	Ni ₈₀ Fe ₂₀	(Fe ₆₀ Ni ₄₀) _{99.7} Ir _{0.3}	(Co ₉₀ Fe ₁₀) _{99.85} Mn _{0.15}	(Co ₅₀ Fe ₅₀) _{99.7} Pt _{0.3}	(Co ₅₀ Fe ₅₀) _{99.7} Pt _{0.3}
		260	33.1						
		300	35.2						
		350	28.4	(Fe ₅₇ Ni ₄₃) _{99.7} Ir _{0.3}	Ni _{78.9} Fe _{21.1}	(Fe ₅₇ Ni ₄₃) _{99.8} Ir _{0.2}	(Co ₉₀ Fe ₁₀) _{99.7} Pt _{0.15} Mn _{0.15}		
		400	24.6	(Fe ₅₄ Ni ₄₆) _{99.7} Ir _{0.3}	Ni _{77.8} Fe _{22.2}	(Fe ₅₄ Ni ₄₆) _{99.8} Ir _{0.2}	(Co ₉₀ Fe ₁₀) _{99.55} Pt _{0.3} Mn _{0.15}		
148	d)	r.t.	16.3	(Fe ₆₀ Ni ₄₀) ₉₇ Ir ₃	Ni ₈₀ Fe ₂₀	(Fe ₆₀ Ni ₄₀) ₉₇ Ir ₃	(Co ₉₀ Fe ₁₀) ₉₉ Mn ₁	(Co ₅₀ Fe ₅₀) ₉₇ Pt ₃	(Co ₅₀ Fe ₅₀) ₉₇ Pt ₃
		260	35.2						
		300	36.7						
		350	32.8	(Fe _{56.9} Ni _{43.1}) _{97.1} Ir _{2.9}	Ni _{78.9} Fe _{21.1}	(Fe _{56.9} Ni _{43.1}) _{97.1} Ir _{2.9}	(Co ₉₀ Fe ₁₀) ₉₈ Pt ₁ Mn ₁		
		400	29.9	(Fe _{53.8} Ni _{46.2}) _{97.3} Ir _{2.7}	Ni _{77.8} Fe _{22.2}	(Fe _{53.8} Ni _{46.2}) _{97.3} Ir _{2.7}	(Co ₉₀ Fe ₁₀) ₉₇ Pt ₂ Mn ₁		

[0073] continued

[Table 22] continued

TABLE 8c)-3

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3
149	d)	r.t.	17.5	$(\text{Co}_{50}\text{Fe}_{50})_{85}\text{Pt}_{15}$	$(\text{Co}_{50}\text{Fe}_{50})_{85}\text{Pt}_{15}$	$(\text{Co}_{90}\text{Fe}_{10})_{95}\text{Mn}_5$
		260	39.2			$(\text{Co}_{90}\text{Fe}_{10})_{90}\text{Pt}_5\text{Mn}_5$
		300	42.4			$(\text{Co}_{90}\text{Fe}_{10})_{85}\text{Pt}_{10}\text{Mn}_5$
		350	42.6			
		400	38.1			
150	d)	r.t.	16.9	$(\text{Co}_{50}\text{Fe}_{50})_{71}\text{Pt}_{29}$	$(\text{Co}_{50}\text{Fe}_{50})_{71}\text{Pt}_{29}$	$(\text{Co}_{90}\text{Fe}_{10})_{90.5}\text{Mn}_{9.5}$
		260	37.8			$(\text{Co}_{90}\text{Fe}_{10})_{81}\text{Pt}_{9.5}\text{Mn}_{9.5}$
		300	38.2			$(\text{Co}_{90}\text{Fe}_{10})_{71.5}\text{Pt}_{19}\text{Mn}_{9.5}$
		350	38.1			
		400	37.9			
151	d)	r.t.	15.2	$(\text{Co}_{50}\text{Fe}_{50})_{41}\text{Pt}_{59}$	$(\text{Co}_{50}\text{Fe}_{50})_{41}\text{Pt}_{59}$	$(\text{Co}_{90}\text{Fe}_{10})_{80.5}\text{Mn}_{19.5}$
		260	34.3			$(\text{Co}_{90}\text{Fe}_{10})_{61}\text{Pt}_{19.5}\text{Mn}_{19.5}$
		300	34.5			$(\text{Co}_{90}\text{Fe}_{10})_{41.5}\text{Pt}_{39}\text{Mn}_{19.5}$
		350	33.6			
		400	33.1			
152	d)	r.t.	13.2	$(\text{Co}_{50}\text{Fe}_{50})_{38}\text{Pt}_{62}$	$(\text{Co}_{50}\text{Fe}_{50})_{38}\text{Pt}_{62}$	$(\text{Co}_{90}\text{Fe}_{10})_{78}\text{Mn}_{21}$
		260	25.9			$(\text{Co}_{90}\text{Fe}_{10})_{58}\text{Pt}_{21}\text{Mn}_{21}$
		300	26.3			$(\text{Co}_{90}\text{Fe}_{10})_{37}\text{Pt}_{42}\text{Mn}_{21}$
		350	14.2			
		400	12.5			

[0073] continued

[Table 22] continued

TABLE 8c)-4

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 4	Composition 5	Composition 6	Composition 7	Composition 8	Composition 9
149	d)	r.t.	17.5	(Fe ₆₀ Ni ₄₀) ₈₅ Ir ₁₅	Ni ₈₀ Fe ₂₀	(Fe ₆₀ Ni ₄₀) ₈₅ Ir ₁₅	(Co ₉₀ Fe ₁₀) ₈₅ Mn ₁₅	(Co ₅₀ Fe ₅₀) ₈₅ Pt ₁₅	(Co ₅₀ Fe ₅₀) ₈₅ Pt ₁₅
		260	39.2						
		300	42.4						
		350	42.6	(Fe _{56.5} Ni _{43.5}) _{85.7} Ir _{14.3}	Ni _{78.9} Fe _{21.1}	(Fe _{56.5} Ni _{43.5}) _{85.7} Ir _{14.3}	(Co ₉₀ Fe ₁₀) ₉₀ Pt ₁ Mn ₅		
		400	38.1	(Fe _{53.1} Ni _{46.9}) _{86.5} Ir _{13.5}	Ni _{77.8} Fe _{22.2}	(Fe _{53.1} Ni _{46.9}) _{86.5} Ir _{13.5}	(Co ₉₀ Fe ₁₀) ₈₅ Pt ₁₀ Mn ₅		
150	d)	r.t.	16.9	(Fe ₆₀ Ni ₄₀) ₇₁ Ir ₂₉	Ni ₈₀ Fe ₂₀	(Fe ₆₀ Ni ₄₀) ₇₁ Ir ₂₉	(Co ₉₀ Fe ₁₀) _{90.5} Mn _{9.5}	(Co ₅₀ Fe ₅₀) ₇₁ Pt ₂₉	(Co ₅₀ Fe ₅₀) ₇₁ Pt ₂₉
		260	37.8						
		300	38.2						
		350	38.1	(Fe _{55.9} Ni _{44.1}) _{72.4} Ir _{27.6}	Ni _{78.9} Fe _{21.1}	(Fe _{55.9} Ni _{44.1}) _{72.4} Ir _{27.6}	(Co ₉₀ Fe ₁₀) ₈₁ Pt _{9.5} Mn _{9.5}		
		400	37.9	(Fe _{51.9} Ni _{48.1}) _{73.9} Ir _{26.1}	Ni _{77.8} Fe _{22.2}	(Fe _{51.9} Ni _{48.1}) _{73.9} Ir _{26.1}	(Co ₉₀ Fe ₁₀) _{71.5} Pt ₁₉ Mn _{9.5}		
151	d)	r.t.	15.2	(Fe ₆₀ Ni ₄₀) ₄₁ Ir ₅₉	Ni ₈₀ Fe ₂₀	(Fe ₆₀ Ni ₄₀) ₄₁ Ir ₅₉	(Co ₉₀ Fe ₁₀) _{80.5} Mn _{19.5}	(Co ₅₀ Fe ₅₀) ₄₁ Pt ₅₉	(Co ₅₀ Fe ₅₀) ₄₁ Pt ₅₉
		260	34.3						
		300	34.5						
		350	33.6	(Fe _{53.2} Ni _{46.8}) _{43.9} Ir _{56.1}	Ni _{78.9} Fe _{21.1}	(Fe _{53.2} Ni _{46.8}) _{43.9} Ir _{56.1}	(Co ₉₀ Fe ₁₀) ₆₁ Pt _{19.5} Mn _{19.5}		
		400	33.1	(Fe _{47.2} Ni _{51.8}) _{46.9} Ir _{53.1}	Ni _{77.8} Fe _{22.2}	(Fe _{47.2} Ni _{51.8}) _{46.9} Ir _{53.1}	(Co ₉₀ Fe ₁₀) _{41.5} Pt ₃₉ Mn _{19.5}		
152	d)	r.t.	13.2	(Fe ₆₀ Ni ₄₀) ₃₃ Ir ₆₇	Ni ₈₀ Fe ₂₀	(Fe ₆₀ Ni ₄₀) ₄₁ Ir ₅₉	(Co ₉₀ Fe ₁₀) ₇₉ Mn ₂₁	(Co ₅₀ Fe ₅₀) ₃₈ Pt ₆₂	(Co ₅₀ Fe ₅₀) ₃₈ Pt ₆₂
		260	25.9						
		300	26.3						
		350	14.2	(Fe _{51.8} Ni _{48.2}) _{36.3} Ir _{63.7}	Ni _{78.9} Fe _{21.1}	(Fe _{51.8} Ni _{48.2}) _{36.3} Ir _{63.7}	(Co ₉₀ Fe ₁₀) ₅₈ Pt ₂₁ Mn ₂₁		
		400	12.5	(Fe _{44.9} Ni _{55.1}) _{39.7} Ir _{60.3}	Ni _{77.8} Fe _{22.2}	(Fe _{44.9} Ni _{55.1}) _{39.7} Ir _{60.3}	(Co ₉₀ Fe ₁₀) ₅₇ Pt ₄₂ Mn ₂₁		

[0074]

[Table 23]

TABLE 8d)-1

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3
153	c)	r.t.	17.2	Co ₅₀ Fe ₅₀	Ni ₅₀ Fe ₅₀	Ni ₅₀ Fe ₅₀
		260	30.4			
		300	31.3			
		350	16.7			
		400	12.2			
154	c)	r.t.	17.3	Co ₅₀ Fe ₅₀	Ni ₅₀ Fe ₅₀	(Ni ₅₀ Fe ₅₀) _{99.8} Pt _{0.2}
		260	30.6			
		300	31.1			
		350	16.5			
		400	13.1			
155	c)	r.t.	17.5	Co ₅₀ Fe ₅₀	Ni ₅₀ Fe ₅₀	(Ni ₅₀ Fe ₅₀) _{99.7} Pt _{0.3}
		260	31.2			
		300	32.4			
		350	27.6			
		400	25.8			
156	c)	r.t.	18.2	Co ₅₀ Fe ₅₀	Ni ₅₀ Fe ₅₀	(Ni ₅₀ Fe ₅₀) ₉₇ Pt ₃
		260	32.9			
		300	33.4			
		350	31.3			
		400	31.1			

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 4	Composition 5	Composition 6	Composition 7	Composition 8	Composition 9
153	c)	r.t.	17.2	Ni ₅₀ Fe ₅₀	Ni ₈₀ Fe ₂₀	Co ₇₅ Fe ₂₅	Co ₇₅ Pt ₂₅	Co ₇₅ Fe ₂₅	Co ₅₀ Pd ₅₀
		260	30.4						
		300	31.3						
		350	16.7						
		400	12.2						
154	c)	r.t.	17.3	Ni ₅₀ Fe ₅₀	Ni ₈₀ Fe ₂₀	Co ₇₅ Fe ₂₅	(Co ₇₅ Fe ₂₅) _{99.8} Pt _{0.14} Mn _{0.05} Cr _{0.03}	Co ₇₅ Fe ₂₅	Co ₅₀ Pd ₅₀
		260	30.6						
		300	31.1						
		350	16.5						
		400	13.1						
155	c)	r.t.	17.5	Ni ₅₀ Fe ₅₀	Ni ₈₀ Fe ₂₀	Co ₇₅ Fe ₂₅	(Co ₇₅ Fe ₂₅) _{99.7} Pt _{0.2} Mn _{0.05} Cr _{0.05}	Co ₇₅ Fe ₂₅	Co ₅₀ Pd ₅₀
		260	31.2						
		300	32.4						
		350	27.6						
		400	25.8						
156	c)	r.t.	18.2	Ni ₅₀ Fe ₅₀	Ni ₈₀ Fe ₂₀	Co ₇₅ Fe ₂₅	(Co ₇₅ Fe ₂₅) ₉₇ Pt ₂ Mn _{0.5} Cr _{0.5}	Co ₇₅ Fe ₂₅	Co ₅₀ Pd ₅₀
		260	32.9						
		300	33.4						
		350	31.3						
		400	31.1						

[0074] continued

[Table 23] continued

TABLE 8d)-3

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 1	Composition 2	Composition 3
157	c)	r.t.	17.9	Co ₅₀ Fe ₅₀	Ni ₅₀ Fe ₅₀	(Ni ₅₀ Fe ₅₀) ₈₅ Pt ₁₅
		260	30.5			
		300	31.1			
		350	32.2			
		400	32.7			
158	c)	r.t.	17.5	Co ₅₀ Fe ₅₀	Ni ₅₀ Fe ₅₀	(Ni ₅₀ Fe ₅₀) ₇₁ Pt ₂₉
		260	29.3			
		300	29.7			
		350	31.3			
		400	31.5			
159	c)	r.t.	15.6	Co ₅₀ Fe ₅₀	Ni ₅₀ Fe ₅₀	(Ni ₅₀ Fe ₅₀) ₄₁ Pt ₅₉
		260	25.4			
		300	26			
		350	27.9			
		400	26.1			
160	c)	r.t.	12.1	Co ₅₀ Fe ₅₀	Ni ₅₀ Fe ₅₀	(Ni ₅₀ Fe ₅₀) ₃₈ Pt ₆₂
		260	20.4			
		300	21.7			
		350	17.2			
		400	13.5			

Sample No.	Element type	Heat treatment temperature (°C)	MR (%)	Composition 4	Composition 5	Composition 6	Composition 7	Composition 8	Composition 9
157	c)	r.t.	17.9	Ni ₅₀ Fe ₅₀	Ni ₈₀ Fe ₂₀	Co ₇₅ Fe ₂₅	(Co ₇₅ Fe ₂₅) ₈₅ Pt ₁₀ Mn _{2.5} Cr _{2.5}	Co ₇₅ Fe ₂₅	Co ₅₀ Pd ₅₀
		260	30.5						
		300	31.1						
		350	32.2						
		400	32.7						
158	c)	r.t.	17.5	Ni ₅₀ Fe ₅₀	Ni ₈₀ Fe ₂₀	Co ₇₅ Fe ₂₅	(Co ₇₅ Fe ₂₅) ₇₁ Pt ₁₉ Mn ₅ Cr ₅	Co ₇₅ Fe ₂₅	Co ₅₀ Pd ₅₀
		260	29.3						
		300	29.7						
		350	31.3						
		400	31.5						
159	c)	r.t.	15.6	Ni ₅₀ Fe ₅₀	Ni ₈₀ Fe ₂₀	Co ₇₅ Fe ₂₅	(Co ₇₅ Fe ₂₅) ₄₁ Pt ₃₉ Mn ₁₀ Cr ₁₀	Co ₇₅ Fe ₂₅	Co ₅₀ Pd ₅₀
		260	25.4						
		300	26						
		350	27.9						
		400	26.1						
160	c)	r.t.	12.1	Ni ₅₀ Fe ₅₀	Ni ₈₀ Fe ₂₀	Co ₇₅ Fe ₂₅	(Co ₇₅ Fe ₂₅) ₃₈ Pt ₄₁ Mn _{10.5} Cr _{10.5}	Co ₇₅ Fe ₂₅	Co ₅₀ Pd ₅₀
		260	20.4						
		300	21.7						
		350	17.2						
		400	13.5						

[0075]

There is a little Mn, which is diffused from the antiferromagnet, at the interface in a region containing a small amount of Pt. However, the diffusion can be suppressed by adding Pt.

5 [0076]

Table 9a) shows the MR characteristics of each sample including Mn and Pt after heat treatment at 350°C and 400°C to MR ratios of a sample to which neither Mn nor Pt is added (i.e., the sample 57). Table 9b) shows the MR characteristics of each sample after heat treatment at 350°C and 400°C
10 to MR ratios of a sample in which the amount of Pt is zero for each addition of Mn.

[0077]

[Table 24]

TABLE 9b)

		Amount of Mn	1	2	3	4	5	6	7	8
TABLE 5d)	0	Amount of Pt	0	0.2	0.3	3	15	29	59	62
		Amount of Pt+Mn	0	0.2	0.3	3	15	29	59	62
		350°C	1	1.02	1.44	1.52	1.61	1.54	1.46	0.98
		400°C	1	1.02	1.92	1.99	2.45	2.21	1.95	1.05
TABLE 6a)	0.2	Amount of Pt	0	0.2	0.3	2.8	14.8	28.8	58.8	61.8
		Amount of Pt+Mn	0.2	0.4	0.5	3	15	29	59	62
		350°C	1	1.03	1.56	1.78	1.81	1.68	1.51	0.99
		400°C	1	1.03	2.21	2.43	2.62	2.51	2.27	1.06
TABLE 6b)	0.5	Amount of Pt	0	0.2	0.3	2.5	14.5	28.5	58.5	61.5
		Amount of Pt+Mn	0.5	0.7	0.8	3	15	29	59	62
		350°C	1	1.01	1.46	1.77	1.97	1.9	1.74	1
		400°C	1	1.01	1.98	2.42	2.73	2.71	2.5	1.06
TABLE 6c)	1	Amount of Pt	0	0.2	0.3	2	14	28	58	61
		Amount of Pt+Mn	1	1.2	1.3	3	15	29	59	62
		350°C	1	1.01	1.45	1.76	2.07	1.96	1.84	1.04
		400°C	1	1.01	1.91	2.4	2.9	2.81	2.61	1.1
TABLE 6d)	2	Amount of Pt	0	0.2	0.3	2	13	27	57	60
		Amount of Pt+Mn	2	2.2	2.3	4	15	29	59	62
		350°C	1	1.01	1.44	1.76	2.17	2.06	1.98	1.06
		400°C	1	1.01	1.9	2.39	3.13	2.98	2.81	1.12
TABLE 7a)	5	Amount of Pt	0	0.2	0.3	2	10	24	54	57
		Amount of Pt+Mn	5	5.2	5.3	7	15	29	59	62
		350°C	1	1.01	1.43	1.7	2.16	1.98	1.86	1.05
		400°C	1	1.01	1.89	2.21	3.04	2.92	2.73	1.11
TABLE 7b)	8	Amount of Pt	0	0.2	0.3	2	7	21	51	54
		Amount of Pt+Mn	8	8.2	8.3	10	15	29	59	62
		350°C	1	1.01	1.39	1.6	1.8	1.69	1.59	1.02
		400°C	1	1.01	1.8	2.09	2.6	2.38	2.27	1.07
TABLE 7c)	12	Amount of Pt	0	0.2	0.3	2	7	17	47	50
		Amount of Pt+Mn	12	12.2	12.3	14	19	29	59	62
		350°C	1	1.01	1.38	1.51	1.6	1.58	1.47	1
		400°C	1	1.01	1.77	2	2.2	2.17	2	1.02
TABLE 7d)	19	Amount of Pt	0	0.2	0.3	2	7	10	40	43
		Amount of Pt+Mn	19	19.2	19.3	21	26	29	59	62
		350°C	1	1	1.36	1.41	1.52	1.44	1.33	0.94
		400°C	1	1	1.71	1.8	1.95	1.87	1.71	0.99
TABLE 8a)	22	Amount of Pt	0	0.2	0.3	2	7	10	37	40
		Amount of Pt+Mn	22	22.2	22.3	24	29	32	59	62
		350°C	1	0.99	1.1	1.11	1.13	1.1	1.01	0.86
		400°C	1	0.99	1.16	1.19	1.21	1.2	0.99	1.01

[0078]

[Table 25]

TABLE 9b)

		Amount of Mn	1	2	3	4	5	6	7	8
TABLE 5d)	0	Amount of Pt	0	0.2	0.3	3	15	29	59	62
		Amount of Pt+Mn	0	0.2	0.3	3	15	29	59	62
		350°C	1	1.02	1.44	1.52	1.61	1.54	1.46	0.98
		400°C	1	1.02	1.92	1.99	2.45	2.21	1.95	1.05
TABLE 6a)	0.2	Amount of Pt	0	0.2	0.3	2.8	14.8	28.8	58.8	61.8
		Amount of Pt+Mn	0.2	0.4	0.5	3	15	29	59	62
		350°C	1	1.03	1.56	1.78	1.81	1.68	1.51	0.99
		400°C	1	1.03	2.21	2.43	2.62	2.51	2.27	1.06
TABLE 6b)	0.5	Amount of Pt	0	0.2	0.3	2.5	14.5	28.5	58.5	61.5
		Amount of Pt+Mn	0.5	0.7	0.8	3	15	29	59	62
		350°C	1	1.01	1.46	1.77	1.97	1.9	1.74	1
		400°C	1	1.01	1.98	2.42	2.73	2.71	2.5	1.06
TABLE 6c)	1	Amount of Pt	0	0.2	0.3	2	14	28	58	61
		Amount of Pt+Mn	1	1.2	1.3	3	15	29	59	62
		350°C	1	1.01	1.45	1.76	2.07	1.96	1.84	1.04
		400°C	1	1.01	1.91	2.4	2.9	2.81	2.61	1.1
TABLE 6d)	2	Amount of Pt	0	0.2	0.3	2	13	27	57	60
		Amount of Pt+Mn	2	2.2	2.3	4	15	29	59	62
		350°C	1	1.01	1.44	1.76	2.17	2.06	1.98	1.06
		400°C	1	1.01	1.9	2.39	3.13	2.98	2.81	1.12
TABLE 7a)	5	Amount of Pt	0	0.2	0.3	2	10	24	54	57
		Amount of Pt+Mn	5	5.2	5.3	7	15	29	59	62
		350°C	1	1.01	1.43	1.7	2.16	1.98	1.86	1.05
		400°C	1	1.01	1.89	2.21	3.04	2.92	2.73	1.11
TABLE 7b)	8	Amount of Pt	0	0.2	0.3	2	7	21	51	54
		Amount of Pt+Mn	8	8.2	8.3	10	15	29	59	62
		350°C	1	1.01	1.39	1.6	1.8	1.69	1.59	1.02
		400°C	1	1.01	1.8	2.09	2.6	2.38	2.27	1.07
TABLE 7c)	12	Amount of Pt	0	0.2	0.3	2	7	17	47	50
		Amount of Pt+Mn	12	12.2	12.3	14	19	29	59	62
		350°C	1	1.01	1.38	1.51	1.6	1.58	1.47	1
		400°C	1	1.01	1.77	2	2.2	2.17	2	1.02
TABLE 7d)	19	Amount of Pt	0	0.2	0.3	2	7	10	40	43
		Amount of Pt+Mn	19	19.2	19.3	21	26	29	59	62
		350°C	1	1	1.36	1.41	1.52	1.44	1.33	0.94
		400°C	1	1	1.71	1.8	1.95	1.87	1.71	0.99
TABLE 8a)	22	Amount of Pt	0	0.2	0.3	2	7	10	37	40
		Amount of Pt+Mn	22	22.2	22.3	24	29	32	59	62
		350°C	1	0.99	1.1	1.11	1.13	1.1	1.01	0.86
		400°C	1	0.99	1.16	1.19	1.21	1.2	0.99	1.01

[0079]

Favorable characteristics were obtained when the amount of addition of Pt was 0.3 to 60 at% and that of Mn was not more than 20 at%, particularly in the range of Mn < Pt. It was confirmed that the characteristics might be improved more by simultaneously adding Mn and Pt than by adding Pt alone in a region where Mn was 8 to 5 at% or less and Mn < Pt. The same tendency was obtained by an element to which Cr or (Mn, Cr) was added in a ratio from 1 : 0.01 to 1 : 100 instead of Mn. Moreover, the same tendency was obtained by adding the elements used in Tables 4a) to 5c) instead of Pt. Further, the same tendency was obtained by using the ferromagnets in Table 4.

[0080]

Tables 8b) to 8d) show the measurements on elements, each having a plurality of barriers due to non-magnets. Even if a plurality of the non-magnets are present, the MR characteristics after heat treatment can be improved by adding the elements in the vicinity of either of the interfaces of at least one of the non-magnets.

[0081]

The compositions between the compositions of the elements shown in Tables 4a) to 9b) are examined at approximately 2 to 10 points, and the experiment is performed so that intervals between the additive compositions are at least 2 at% or less, and the results of approximately a third part of the combinations shown in the tables and notes and the features thereof are shown. The compositions therebetween have the similar results.

[0082]

Tables 4a) to 9b) show the results of heat treatment up to 400°C. However, some samples were heat-treated at 400°C to 540°C in increments of 10°C, thus measuring the MR characteristics. Consequently, the magnetoresistive element that included the additional element in an amount of 0.3 to 60 at% had excellent MR characteristics after heat treatment up to 450°C as compared with the element that did not include the element. In particular, when the amount of addition was 3 to 30 at%, excellent MR characteristics were obtained after heat treatment up to 500°C as compared with the element that did not include the element. The same measurement was performed on the element to which Mn and Cr (the additional element) were added simultaneously with the main additional element. Consequently, the magnetoresistive element that included 0.3 to

60 at% of the main additional element and achieved Mn and Cr < the main additional element had relatively excellent MR characteristics after heat treatment up to 450°C. Moreover, the element that included 3 to 30 at% of the main additional element and less than 8 at% of Mn and Cr, and achieved

5 Mn and Cr < the main additional element had relatively excellent MR characteristics after heat treatment up to 500°C as compared with the element that included neither Mn, Cr or the additional element.

[0083]

The above description shows the results obtained when an AlO film formed by natural oxidation is used as the non-magnet. However, the same tendency can be obtained by using the following films as the non-magnet: AlO with plasma oxidation; AlO with ion radical oxidation; AlO with reactive evaporation; AlN with natural nitridation; AlN with plasma nitridation; AlN with reactive evaporation; BN with plasma nitridation or reactive evaporation; TaO with thermal oxidation, plasma oxidation, or ion radical oxidation; AlSiO with thermal oxidation, natural oxidation, or plasma oxidation; and AlON with natural oxynitridation, plasma oxynitridation, or reactive sputtering.

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[0084]

The same tendency can be obtained by using FeMn, NiMn, IrMn, PtMn, RhMn, CrMnPt, CrAl, CrRu, CrRh, CrOs, CrIr, CrPt, or TbCo as the antiferromagnet instead of PdPtMn.

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[0085]

The same tendency can be obtained by using Rh (thickness: 0.4 to 1.9 nm), Ir (0.3 to 1.4 nm), or Cr (0.9 to 1.4 nm) as the non-magnetic metal instead of Ru (0.7 to 0.9 nm).

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[0086]

Basically the same tendency can be obtained from each of the elements having the configurations shown in the drawings.

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[0087]

(A third embodiment)

In this example, magnetoresistive elements were produced by the same methods of film forming and processing as those in Examples 1 and 2. The composition of the film was measured by Auger electron spectroscopy, SIMS and XPS. An AlON film (thickness: 1.0 to 2 nm) was used as the non-magnet. The AlON film was produced by oxynitriding an Al film in a chamber filled with a mixed gas of pure oxygen and high purity nitrogen

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with a ratio of 1 : 1. Rh (1.4 to 1.9 nm) was used as the non-magnetic metal film, and PtMn (20 to 30 nm) was used as the antiferromagnet. The element configuration and the ferromagnets were the same as those of the samples shown in Tables 5d) to 8a). In this example, the effect of adding Ta and N was measured in addition to Pt and Mn. Like Example 2, the characteristics after heat treatment up to 540°C were examined. Here, the measurements at 350°C and 400°C, both indicating distinctive features, were described. In this example, a coercive force of the free layer was measured as the magnetic characteristics. Tables 10 to 22 report the coercive force relative to the composition of elements present at each of the interfaces. The magnetic characteristics of the samples whose coercive forces are not shown in Tables cannot be measured. The addition of Ta and N improves the soft magnetic characteristics. However, when the amount of non-magnetic additives is not less than about 70 at%, it is impossible to measure the magnetic characteristics. The MR characteristics of the samples in Tables 10, 11, 12, 15, 16, 19 and 20 are within $\pm 10\%$ after heat treatment, compared with the element that does not include Ta and N. The MR characteristics of the samples in Tables 13, 17 and 21 are degraded by about 10 to 20%, and those of the samples in Tables 14, 18 and 22 are degraded by about 50 to 60%.

[0088]

The same tendency can be obtained by replacing Ta with Ti, Zr, Hf, V, Nb, Mo, W, Al, Si, Ga, Ge, In or Sn. Moreover, the same tendency can be obtained by replacing N with B, C or O.

[0089]

[Table 26]

TABLE 10 ($T_a = 0$, $N = 0$)

Amount of Mn									
0	Amount of Pt	0	0.2	0.3	3	15	29	59	62
	Total amount of additional elements	0	0.2	0.3	3	15	29	59	62
	350°C	98	98	99	113	127	147	196	196
	400°C	88	88	89	101	115	132	176	176
0.5	Amount of Pt	0	0.2	0.3	2.5	14.5	28.5	58.5	61.5
	Total amount of additional elements	0.5	0.7	0.8	3	15	29	59	62
	350°C	97	97	98	112	126	146	194	194
	400°C	87	87	88	100	114	131	175	175
1	Amount of Pt	0	0.2	0.3	2	14	28	58	61
	Total amount of additional elements	1	1.2	1.3	3	15	29	59	62
	350°C	93	93	94	107	121	140	186	186
	400°C	84	84	85	96	109	126	168	168
5	Amount of Pt	0	0.2	0.3	2	10	24	54	57
	Total amount of additional elements	5	5.2	5.3	7	15	29	59	62
	350°C	88	88	89	101	115	132	176	176
	400°C	79	79	80	91	103	119	159	159
8	Amount of Pt	0	0.2	0.3	2	7	21	51	54
	Total amount of additional elements	8	8.2	8.3	10	15	29	59	62
	350°C	93	93	94	107	121	140	186	186
	400°C	84	84	85	96	109	126	168	168
19	Amount of Pt	0	0.2	0.3	2	7	10	40	43
	Total amount of additional elements	19	19.2	19.3	21	26	29	59	62
	350°C	96	96	97	110	125	144	192	192
	400°C	86	86	87	99	112	130	173	173
22	Amount of Pt	0	0.2	0.3	2	7	10	37	40
	Total amount of additional elements	22	22.2	22.3	24	29	32	59	62
	350°C	100	100	101	115	130	150	200	200
	400°C	90	90	91	103	117	135	180	180

[0090]

[Table 27]

TABLE 11(Ta = 1, N = 0)

Amount of Mn									
0	Amount of Pt Total amount of additional elements	0	0.2	0.3	3	15	29	59	62
		1	1.2	1.3	4	16	30	60	63
	350°C	99	99	100	114	129	149	198	198
	400°C	89	89	90	102	116	134	178	178
0.5	Amount of Pt Total amount of additional elements	0	0.2	0.3	2.5	14.5	28.5	58.5	61.5
		1.5	1.7	1.8	4	16	30	60	63
	350°C	98	98	99	113	127	147	196	196
	400°C	88	88	89	101	115	132	176	176
1	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	14	28	58	61
		2	2.2	2.3	4	16	30	60	63
	350°C	94	94	95	108	122	141	188	188
	400°C	85	85	85	97	110	127	169	169
5	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	10	24	54	57
		6	6.2	6.3	8	16	30	60	63
	350°C	89	89	90	102	116	134	178	178
	400°C	80	80	81	92	104	120	160	160
8	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	7	21	51	54
		9	9.2	9.3	11	16	30	60	63
	350°C	94	94	95	108	122	141	188	188
	400°C	85	85	85	97	110	127	169	169
19	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	7	10	40	43
		20	20.2	20.3	22	27	30	60	63
	350°C	97	97	98	112	126	146	194	194
	400°C	87	87	88	100	114	131	175	175
22	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	7	10	37	40
		23	23.2	23.3	25	30	33	60	63
	350°C	101	101	102	116	131	151	202	202
	400°C	91	91	92	105	118	136	182	182

[0091]

[Table 28]

TABLE 12 ($T_a = 15$, $N = 0$)

Amount of Mn									
0	Amount of Pt	0	0.2	0.3	3	15	29	59	62
	Total amount of additional elements	15	15.2	15.3	18	30	44	74	77
	350°C	58	58	59	67	75	87	—	—
	400°C	52	52	53	60	68	78	—	—
0.5	Amount of Pt	0	0.2	0.3	2.5	14.5	28.5	58.5	61.5
	Total amount of additional elements	15.5	15.7	15.8	18	30	44	74	77
	350°C	57	57	58	66	75	86	—	—
	400°C	52	52	52	59	67	78	—	—
1	Amount of Pt	0	0.2	0.3	2	14	28	58	61
	Total amount of additional elements	16	16.2	16.3	18	30	44	74	77
	350°C	55	55	56	63	72	83	—	—
	400°C	50	50	50	57	64	74	—	—
5	Amount of Pt	0	0.2	0.3	2	10	24	54	57
	Total amount of additional elements	20	20.2	20.3	22	30	44	74	77
	350°C	52	52	53	60	68	78	—	—
	400°C	47	47	47	54	61	70	—	—
8	Amount of Pt	0	0.2	0.3	2	7	21	51	54
	Total amount of additional elements	23	23.2	23.3	25	30	44	74	77
	350°C	55	55	56	63	72	83	—	—
	400°C	50	50	50	57	64	74	—	—
19	Amount of Pt	0	0.2	0.3	2	7	10	40	43
	Total amount of additional elements	34	34.2	34.3	36	41	44	74	77
	350°C	57	57	57	65	74	85	—	—
	400°C	51	51	52	59	67	77	—	—
22	Amount of Pt	0	0.2	0.3	2	7	10	37	40
	Total amount of additional elements	37	37.2	37.3	39	44	47	74	77
	350°C	59	59	60	68	77	89	—	—
	400°C	53	53	54	61	69	80	—	—

[0092]

[Table 29]

TABLE 13 (Ta = 29, N = 0)

Amount of Mn									
0	Amount of Pt	0	0.2	0.3	3	15	29	59	62
	Total amount of additional elements	29	29.2	29.3	32	44	58	88	91
	350°C	22	22	22	25	29	33	—	—
	400°C	20	20	20	23	26	30	—	—
0.5	Amount of Pt	0	0.2	0.3	2.5	14.5	28.5	58.5	61.5
	Total amount of additional elements	29.5	29.7	29.8	32	44	58	88	91
	350°C	22	22	22	25	28	33	—	—
	400°C	20	20	20	23	25	29	—	—
1	Amount of Pt	0	0.2	0.3	2	14	28	58	61
	Total amount of additional elements	30	30.2	30.3	32	44	58	88	91
	350°C	21	21	21	24	27	31	—	—
	400°C	19	19	19	22	24	28	—	—
5	Amount of Pt	0	0.2	0.3	2	10	24	54	57
	Total amount of additional elements	34	34.2	34.3	36	44	58	88	91
	350°C	20	20	20	23	26	30	—	—
	400°C	18	18	18	20	23	27	—	—
8	Amount of Pt	0	0.2	0.3	2	7	21	51	54
	Total amount of additional elements	37	37.2	37.3	39	44	58	88	91
	350°C	21	21	21	24	27	31	—	—
	400°C	19	19	19	22	24	28	—	—
19	Amount of Pt	0	0.2	0.3	2	7	10	40	43
	Total amount of additional elements	48	48.2	48.3	50	55	58	88	91
	350°C	22	22	22	25	28	32	—	—
	400°C	19	19	20	22	25	29	—	—
22	Amount of Pt	0	0.2	0.3	2	7	10	37	40
	Total amount of additional elements	51	51.2	51.3	53	58	61	88	91
	350°C	22	22	23	26	29	34	—	—
	400°C	20	20	20	23	26	30	—	—

[0093]

[Table 30]

TABLE 14 ($T_a = 31$, $N = 0$)

Amount of Mn									
0	Amount of Pt Total amount of additional elements	0	0.2	0.3	3	15	29	59	62
		31	31.2	31.3	34	46	60	90	93
	350°C 400°C	18	18	18	21	23	27	—	—
		16	16	16	19	21	24	—	—
0.5	Amount of Pt Total amount of additional elements	0	0.2	0.3	2.5	14.5	28.5	58.5	61.5
		31.5	31.7	31.8	34	46	60	90	93
	350°C 400°C	18	18	18	20	23	27	—	—
		16	16	16	18	21	24	—	—
1	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	14	28	58	61
		32	32.2	32.3	34	46	60	90	93
	350°C 400°C	17	17	17	20	22	26	—	—
		15	15	16	18	20	23	—	—
5	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	10	24	54	57
		36	36.2	36.3	38	46	60	90	93
	350°C 400°C	16	16	16	19	21	24	—	—
		15	15	15	17	19	22	—	—
8	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	7	21	51	54
		39	39.2	39.3	41	46	60	90	93
	350°C 400°C	17	17	17	20	22	26	—	—
		15	15	16	18	20	23	—	—
19	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	7	10	40	43
		50	50.2	50.3	52	57	60	90	93
	350°C 400°C	18	18	18	20	23	26	—	—
		16	16	16	18	21	24	—	—
22	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	7	10	37	40
		53	53.2	53.3	55	60	63	90	93
	350°C 400°C	18	18	19	21	24	28	—	—
		17	17	17	19	21	25	—	—

[0094]

[Table 31]

TABLE 15 ($T_a = 0$, $N = 1$)

Amount of Mn									
0	Amount of Pt Total amount of additional elements	0	0.2	0.3	3	15	29	59	62
		1	1.2	1.3	4	16	30	60	63
	350°C	101	101	102	116	131	152	202	202
		91	91	92	105	118	136	182	182
0.5	Amount of Pt Total amount of additional elements	0	0.2	0.3	2.5	14.5	28.5	58.5	61.5
		1.5	1.7	1.8	4	16	30	60	63
	350°C	100	100	101	115	130	150	200	200
		90	90	91	103	117	135	180	180
1	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	14	28	58	61
		2	2.2	2.3	4	16	30	60	63
	350°C	96	96	97	110	125	144	192	192
		86	86	87	99	112	130	173	173
5	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	10	24	54	57
		6	6.2	6.3	8	16	30	60	63
	350°C	91	91	92	105	118	136	182	182
		82	82	83	94	106	123	164	164
8	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	7	21	51	54
		9	9.2	9.3	11	16	30	60	63
	350°C	96	96	97	110	125	144	192	192
		86	86	87	99	112	130	173	173
19	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	7	10	40	43
		20	20.2	20.3	22	27	30	60	63
	350°C	99	99	100	114	129	148	198	198
		89	89	90	102	116	134	178	178
22	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	7	10	37	40
		23	23.2	23.3	25	30	33	60	63
	350°C	103	103	104	118	134	155	206	206
		93	93	94	107	121	139	185	185

[0095]

[Table 32]

TABLE 16 ($T_a = 0$, $N = 10$)

Amount of Mn									
0	Amount of Pt Total amount of additional elements	0	0.2	0.3	3	15	29	59	62
		10	10.2	10.3	13	25	39	69	72
	350°C 400°C	62	62	63	71	81	93	—	—
		56	56	56	64	73	84	—	—
0.5	Amount of Pt Total amount of additional elements	0	0.2	0.3	2.5	14.5	28.5	58.5	61.5
		10.5	10.7	10.8	13	25	39	69	72
	350°C 400°C	61	61	62	71	80	92	—	—
		55	55	56	64	72	83	—	—
1	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	14	28	58	61
		11	11.2	11.3	13	25	39	69	72
	350°C 400°C	59	59	59	68	77	88	—	—
		53	53	54	61	69	80	—	—
5	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	10	24	54	57
		15	15.2	15.3	17	25	39	69	72
	350°C 400°C	56	56	56	64	73	84	—	—
		50	50	51	58	65	75	—	—
8	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	7	21	51	54
		18	18.2	18.3	20	25	39	69	72
	350°C 400°C	59	59	59	68	77	88	—	—
		53	53	54	61	69	80	—	—
19	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	7	10	40	43
		29	29.2	29.3	31	36	39	69	72
	350°C 400°C	61	61	61	70	79	91	—	—
		55	55	55	63	71	82	—	—
22	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	7	10	37	40
		32	32.2	32.3	34	39	42	69	72
	350°C 400°C	63	63	64	73	82	95	—	—
		57	57	57	65	74	85	—	—

[0096]

[Table 33]

TABLE 17 ($T_a = 0$, $N = 19$)

Amount of Mn									
0	Amount of Pt Total amount of additional elements	0	0.2	0.3	3	15	29	59	62
		19	19.2	19.3	22	34	48	78	81
	350°C 400°C	25	25	25	29	33	38	—	—
		23	23	23	26	29	34	—	—
0.5	Amount of Pt Total amount of additional elements	0	0.2	0.3	2.5	14.5	28.5	58.5	61.5
		19.5	19.7	19.8	22	34	48	78	81
	350°C 400°C	25	25	25	28	32	37	—	—
		22	22	22	26	29	33	—	—
1	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	14	28	58	61
		20	20.2	20.3	22	34	48	78	81
	350°C 400°C	24	24	24	27	31	36	—	—
		21	21	22	25	28	32	—	—
5	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	10	24	54	57
		24	24.2	24.3	26	34	48	78	81
	350°C 400°C	23	23	23	26	29	34	—	—
		20	20	20	23	26	30	—	—
8	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	7	21	51	54
		27	27.2	27.3	29	34	48	78	81
	350°C 400°C	24	24	24	27	31	36	—	—
		21	21	22	25	28	32	—	—
19	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	7	10	40	43
		38	38.2	38.3	40	45	48	78	81
	350°C 400°C	25	25	25	28	32	37	—	—
		22	22	22	25	29	33	—	—
22	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	7	10	37	40
		41	41.2	41.3	43	48	51	78	81
	350°C 400°C	26	26	26	29	33	38	—	—
		23	23	23	26	30	34	—	—

[0097]

[Table 34]

TABLE 18 ($T_a = 0$, $N = 21$)

Amount of Mn									
0	Amount of Pt	0	0.2	0.3	3	15	29	59	62
	Total amount of additional elements	21	21.2	21.3	24	36	50	80	83
	350°C	21	21	21	24	27	32	—	—
	400°C	19	19	19	22	25	28	—	—
0.5	Amount of Pt	0	0.2	0.3	2.5	14.5	28.5	58.5	61.5
	Total amount of additional elements	21.5	21.7	21.8	24	36	50	80	83
	350°C	21	21	21	24	27	31	—	—
	400°C	19	19	19	22	24	28	—	—
1	Amount of Pt	0	0.2	0.3	2	14	28	58	61
	Total amount of additional elements	22	22.2	22.3	24	36	50	80	83
	350°C	20	20	20	23	26	30	—	—
	400°C	18	18	18	21	23	27	—	—
5	Amount of Pt	0	0.2	0.3	2	10	24	54	57
	Total amount of additional elements	26	26.2	26.3	28	36	50	80	83
	350°C	19	19	19	22	25	28	—	—
	400°C	17	17	17	20	22	26	—	—
8	Amount of Pt	0	0.2	0.3	2	7	21	51	54
	Total amount of additional elements	29	29.2	29.3	31	36	50	80	83
	350°C	20	20	20	23	26	30	—	—
	400°C	18	18	18	21	23	27	—	—
19	Amount of Pt	0	0.2	0.3	2	7	10	40	43
	Total amount of additional elements	40	40.2	40.3	42	47	50	80	83
	350°C	21	21	21	24	27	31	—	—
	400°C	19	19	19	21	24	28	—	—
22	Amount of Pt	0	0.2	0.3	2	7	10	37	40
	Total amount of additional elements	43	43.2	43.3	45	50	53	80	83
	350°C	21	21	22	25	28	32	—	—
	400°C	19	19	19	22	25	29	—	—

[0098]

[Table 35]

TABLE 19 ($T_a = 3$, $N = 2$)

Amount of Mn									
0	Amount of Pt	0	0.2	0.3	3	15	29	59	62
	Total amount of additional elements	5	5.2	5.3	8	20	34	64	67
	350°C	79	79	80	91	103	119	158	158
	400°C	71	71	72	82	92	107	142	142
0.5	Amount of Pt	0	0.2	0.3	2.5	14.5	28.5	58.5	61.5
	Total amount of additional elements	5.5	5.7	5.8	8	20	34	64	67
	350°C	78	78	79	90	102	117	156	156
	400°C	70	70	71	81	92	106	141	141
1	Amount of Pt	0	0.2	0.3	2	14	28	58	61
	Total amount of additional elements	6	6.2	6.3	8	20	34	64	67
	350°C	75	75	76	86	98	113	150	150
	400°C	68	68	68	78	88	101	135	135
5	Amount of Pt	0	0.2	0.3	2	10	24	54	57
	Total amount of additional elements	10	10.2	10.3	12	20	34	64	67
	350°C	71	71	72	82	92	107	142	142
	400°C	64	64	65	74	83	96	128	128
8	Amount of Pt	0	0.2	0.3	2	7	21	51	54
	Total amount of additional elements	13	13.2	13.3	15	20	34	64	67
	350°C	75	75	76	86	98	113	150	150
	400°C	68	68	68	78	88	101	135	135
19	Amount of Pt	0	0.2	0.3	2	7	10	40	43
	Total amount of additional elements	24	24.2	24.3	26	31	34	64	67
	350°C	77	77	78	89	101	116	155	155
	400°C	70	70	70	80	91	105	139	139
22	Amount of Pt	0	0.2	0.3	2	7	10	37	40
	Total amount of additional elements	27	27.2	27.3	29	34	37	64	67
	350°C	81	81	81	93	105	121	161	161
	400°C	73	73	73	83	94	109	145	145

[0099]

[Table 36]

TABLE 20 ($T_a = 14$, $N = 7$)

Amount of Mn									
0	Amount of Pt	0	0.2	0.3	3	15	29	59	62
	Total amount of additional elements	21	21.2	21.3	24	36	50	80	83
	350°C	38	38	38	44	49	57	—	—
	400°C	34	34	35	39	44	51	—	—
0.5	Amount of Pt	0	0.2	0.3	2.5	14.5	28.5	58.5	61.5
	Total amount of additional elements	21.5	21.7	21.8	24	36	50	80	83
	350°C	38	38	38	43	49	56	—	—
	400°C	34	34	34	39	44	51	—	—
1	Amount of Pt	0	0.2	0.3	2	14	28	58	61
	Total amount of additional elements	22	22.2	22.3	24	36	50	80	83
	350°C	36	36	36	42	47	54	—	—
	400°C	32	32	33	37	42	49	—	—
5	Amount of Pt	0	0.2	0.3	2	10	24	54	57
	Total amount of additional elements	26	26.2	26.3	28	36	50	80	83
	350°C	34	34	35	39	44	51	—	—
	400°C	31	31	31	35	40	46	—	—
8	Amount of Pt	0	0.2	0.3	2	7	21	51	54
	Total amount of additional elements	29	29.2	29.3	31	36	50	80	83
	350°C	36	36	36	42	47	54	—	—
	400°C	32	32	33	37	42	49	—	—
19	Amount of Pt	0	0.2	0.3	2	7	10	40	43
	Total amount of additional elements	40	40.2	40.3	42	47	50	80	83
	350°C	37	37	38	43	48	56	—	—
	400°C	34	34	34	39	44	50	—	—
22	Amount of Pt	0	0.2	0.3	2	7	10	37	40
	Total amount of additional elements	43	43.2	43.3	45	50	53	80	83
	350°C	39	39	39	45	50	58	—	—
	400°C	35	35	35	40	45	52	—	—

[0100]

[Table 37]

TABLE 21 (Ta = 29, N = 19)

Amount of Mn									
0	Amount of Pt Total amount of additional elements	0	0.2	0.3	3	15	29	59	62
		48	48.2	48.3	51	63	77	107	110
	350°C 400°C	5	5	5	6	7	—	—	—
		5	5	5	5	6	—	—	—
0.5	Amount of Pt Total amount of additional elements	0	0.2	0.3	2.5	14.5	28.5	58.5	61.5
		48.5	48.7	48.8	51	63	77	107	110
	350°C 400°C	5	5	5	6	6	—	—	—
		4	4	4	5	6	—	—	—
1	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	14	28	58	61
		49	49.2	49.3	51	63	77	107	110
	350°C 400°C	5	5	5	5	6	—	—	—
		4	4	4	5	6	—	—	—
5	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	10	24	54	57
		53	53.2	53.3	55	63	77	107	110
	350°C 400°C	5	5	5	5	6	—	—	—
		4	4	4	5	5	—	—	—
8	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	7	21	51	54
		56	56.2	56.3	58	63	77	107	110
	350°C 400°C	5	5	5	5	6	—	—	—
		4	4	4	5	6	—	—	—
19	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	7	10	40	43
		67	67.2	67.3	69	74	77	107	110
	350°C 400°C	5	5	5	6	—	—	—	—
		4	4	4	5	—	—	—	—
22	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	7	10	37	40
		70	70.2	70.3	72	77	80	107	110
	350°C 400°C	5	5	5	—	—	—	—	—
		5	5	5	—	—	—	—	—

[0101]

[Table 38]

TABLE 22 ($T_a = 31$, $N = 21$)

Amount of Mn									
0	Amount of Pt Total amount of additional elements	0	0.2	0.3	3	15	29	59	62
		52	52.2	52.3	55	67	81	111	114
	350°C 400°C	5	5	5	5	6	—	—	—
		4	4	4	5	5	—	—	—
0.5	Amount of Pt Total amount of additional elements	0	0.2	0.3	2.5	14.5	28.5	58.5	61.5
		52.5	52.7	52.8	55	67	81	111	114
	350°C 400°C	4	4	4	5	6	—	—	—
		4	4	4	5	5	—	—	—
1	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	14	28	58	61
		53	53.2	53.3	55	67	81	111	114
	350°C 400°C	4	4	4	5	6	—	—	—
		4	4	4	4	5	—	—	—
5	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	10	24	54	57
		57	57.2	57.3	59	67	81	111	114
	350°C 400°C	4	4	4	5	5	—	—	—
		4	4	4	4	5	—	—	—
8	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	7	21	51	54
		60	60.2	60.3	62	67	81	111	114
	350°C 400°C	4	4	4	5	6	—	—	—
		4	4	4	4	5	—	—	—
19	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	7	10	40	43
		71	71.2	71.3	73	78	81	111	114
	350°C 400°C	—	—	—	—	—	—	—	—
		—	—	—	—	—	—	—	—
22	Amount of Pt Total amount of additional elements	0	0.2	0.3	2	7	10	37	40
		74	74.2	74.3	76	81	84	111	114
	350°C 400°C	—	—	—	—	—	—	—	—
		—	—	—	—	—	—	—	—

[0102]

(A fourth embodiment)

In this example, magnetoresistive elements were produced by the same method of film forming and processing as those in Examples 1 to 3.

- 5 An AlOx film (thickness: 1.0 to 2 nm) was used as the non-magnet. The AlOx film was produced by oxidizing an Al film with an ion radical source of O. Ir (1.2 to 1.4 nm) was used as the non-magnetic metal layer, and NiMn (30 to 40 nm) was used as the antiferromagnet. The element configuration and the ferromagnets were the same as those of the samples shown in
- 10 Tables 4 to 8. In this example, Pt, Pr and Au were added to examine the MR characteristics after each of the heat treatments and the stability of solid solution. The solid solution was evaluated in the following manner. First, the elements were heat-treated at different temperatures of 350°C, 400°C, 450°C and 500°C. Then, the composition at the interfaces of the
- 15 non-magnet of each of the elements was determined, e.g., by XPS analysis after AES depth profile, SIMS, and milling. Next, alloy samples having the composition thus determined were produced separately, which then were heat-treated in the atmosphere of a reduced pressure (10^{-5} Pa) at 350°C, 400°C, 450°C and 500°C for 24 hours. The surfaces of the alloy samples
- 20 were etched chemically and observed with a metallurgical microscope. After etching, ion milling was performed in the atmosphere of a reduced pressure, followed by structural observation with a scanning electron microscope (SEM) and in-plane composition analysis with EDX. Finally, whether the alloy samples had a single phase was evaluated based on the
- 25 measurements.

[0103]

- When composition distribution and a plurality of phases were observed in the alloy sample whose heat treatment temperature and composition corresponded to those of the magnetoresistive element, the MR
- 30 characteristics of this element were improved by about 30 to 100%, compared with the element that did not include the additive element or the like. When the alloy sample showed a single phase, the MR characteristics of the corresponding element were improved by about 80 to 200%, compared with the element that included no additional element. The element that
- 35 corresponded to the alloy sample having a stable single phase provided even more favorable MR characteristics after heat treatment.

[0104]



(A fifth embodiment)

Using the samples in Tables 4d), 5a), 5c), and 5d) of Example 2, the diffusion effect of Mn observed after heat treatment was controlled by appropriately changing the distance between the interface of antiferromagnet/ferromagnet and the interface of ferromagnet/non-magnet and heat treatment temperatures. Here, the heat treatment temperature was 300°C or more. This control was performed so that Mn at the interfaces of the non-magnet was 20 to 0.5 at% after heat treatment. When the distance was less than 3 nm, the content of the magnetic elements (Fe, Co, Ni) was reduced to 40 at% or less after heat treatment even with the addition of Pt or the like, resulting in a significant degradation of the MR characteristics. When the distance was more than 50 nm, heat treatment at 400°C or more was required only for increasing the content of Mn at the interfaces by 0.5 at%. A sufficient effect of fixing the magnetization directions of the ferromagnets was not obtained from the antiferromagnet, resulting in a significant degradation of the MR characteristics after heat treatment.

[0105]

[Effects of the invention]

As mentioned above, according to the present invention, a high MR characteristics can be obtained by allowing a roughness of an interface of a non-magnet to be 20 nm or less after a heat treatment of a magnet at 300°C or more.

[0106]

Moreover, by limiting compositions of a magnet and a non-magnet, a magnetoresistive element with high MR characteristics and excellent magnetic characteristics can be obtained.

[0107]

Furthermore, by allowing a composition of the magnet at an interface with a non-magnet to be alloy that has a single phase at temperature of heat treatment, a magnetoresistive element with excellent stability can be obtained.

[0108]

Still further, in a magnetoresistive element having an antiferromagnet, by allowing a distance from an interface between a ferromagnet and a non-magnet to the antiferromagnet to be in a range between 3 nm and 50 nm inclusive, a magnetoresistive element with high

heat-resistance can be formed.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[FIG.1]

5 FIGS. 1 is a schematic view of a magnetoresistive element for
evaluation.

[FIG.2]

FIG. 2 is a view for describing a definition of R1 and the radius of
curvature of the present invention.

10 [FIG.3]

FIG. 3 is a view showing an example of a structure of the
magnetoresistive element of the present invention.

[FIG.4]

15 FIG. 4 is a schematic view of the magnetoresistive element of
Example 2 and 3.



2001-192217

[Document Name] ABSTRACT

[Abstract]

[Object] It is an object of the present invention to provide an AC plasma display panel in which the occurrence of unevenness in display luminance and error display are suppressed.

[Means to Solve the Problems] A plurality of sustain electrodes 4a and 4b and scanning electrodes 5, which are covered with a dielectric layer 2 and a protective film 3, are provided in parallel on a first insulating substrate 1. A sustain electrode 4a, a scanning electrode 5, and a sustain electrode 4b are formed sequentially to constitute one set of electrodes and a plurality of such sets are provided in parallel. On a second insulating substrate 6, a plurality of data electrodes 7 are provided. Between the respective data electrodes 7, a plurality of separation walls 8 are provided in parallel to the data electrodes 7. Phosphors 9 are provided on the plurality of data electrodes 7 and side faces of the plurality of separation walls 8. The first insulating substrate 1 and the second insulating substrate 6 are positioned opposing each other so that the sustain electrodes 4a, the scanning electrodes 5, and the sustain electrodes 4b are orthogonal to the data electrodes 7.

[Selected Figure] Fig. 1

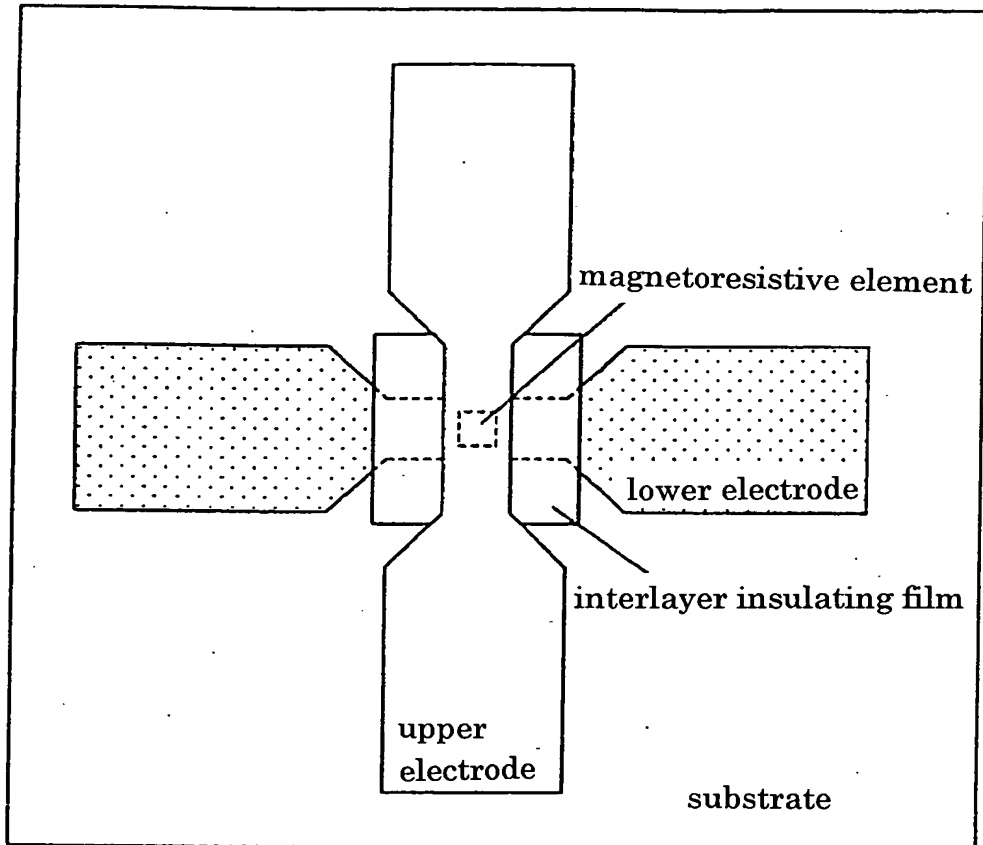


2001-192217

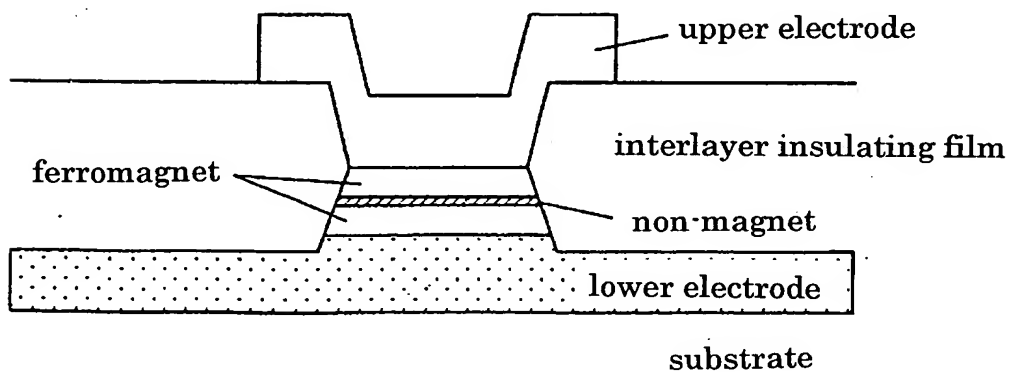
[Document Name] Drawings

[FIG. 1]

(a) schematic view of magnetoresistive element for evaluation

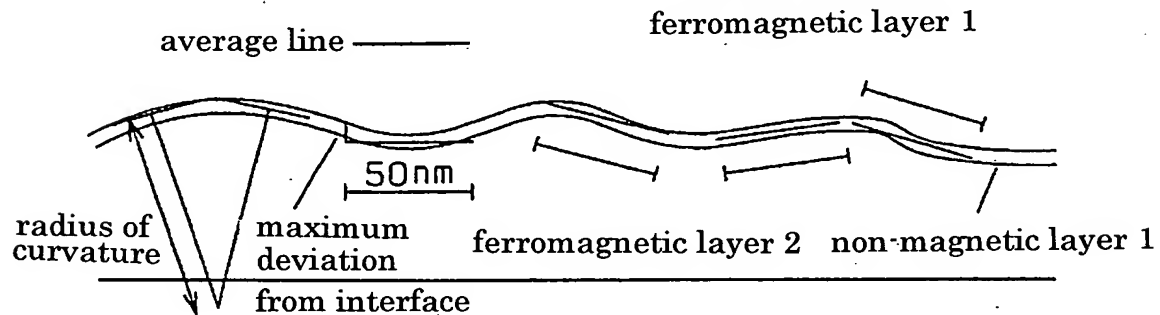


(b) cross-sectional view

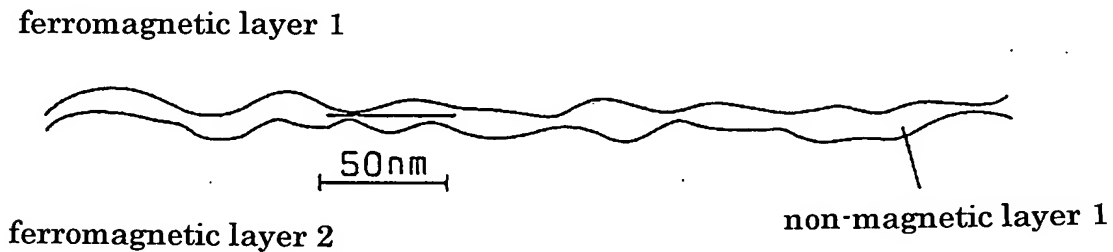


[FIG. 2] view for describing a definition of R1 and the radius of curvature of the present invention

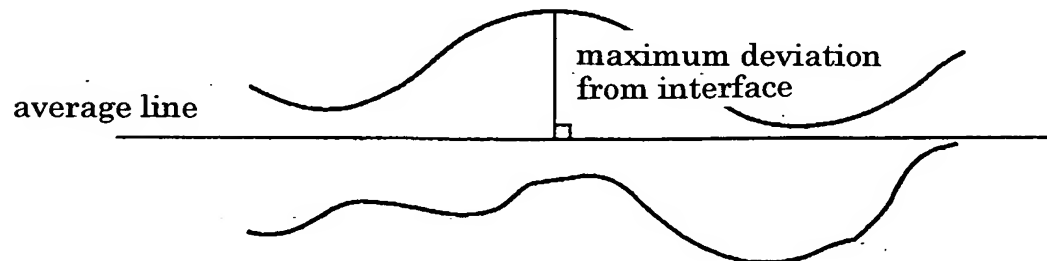
- (a) Among deviations from an average line to an interface, a maximum value is set to be roughness in the range



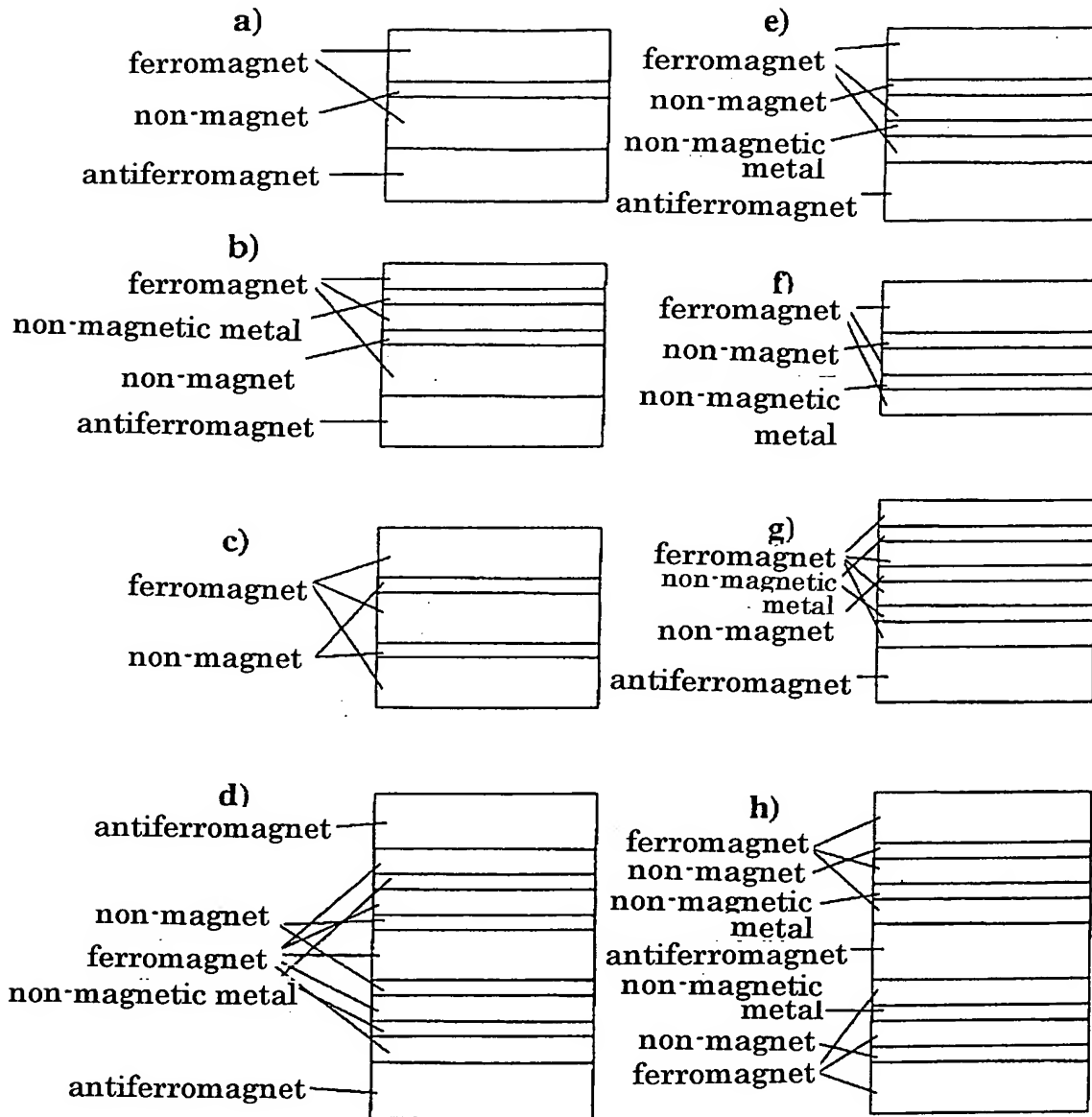
- (b)



- (c) enlarged view in the vicinity of an interface

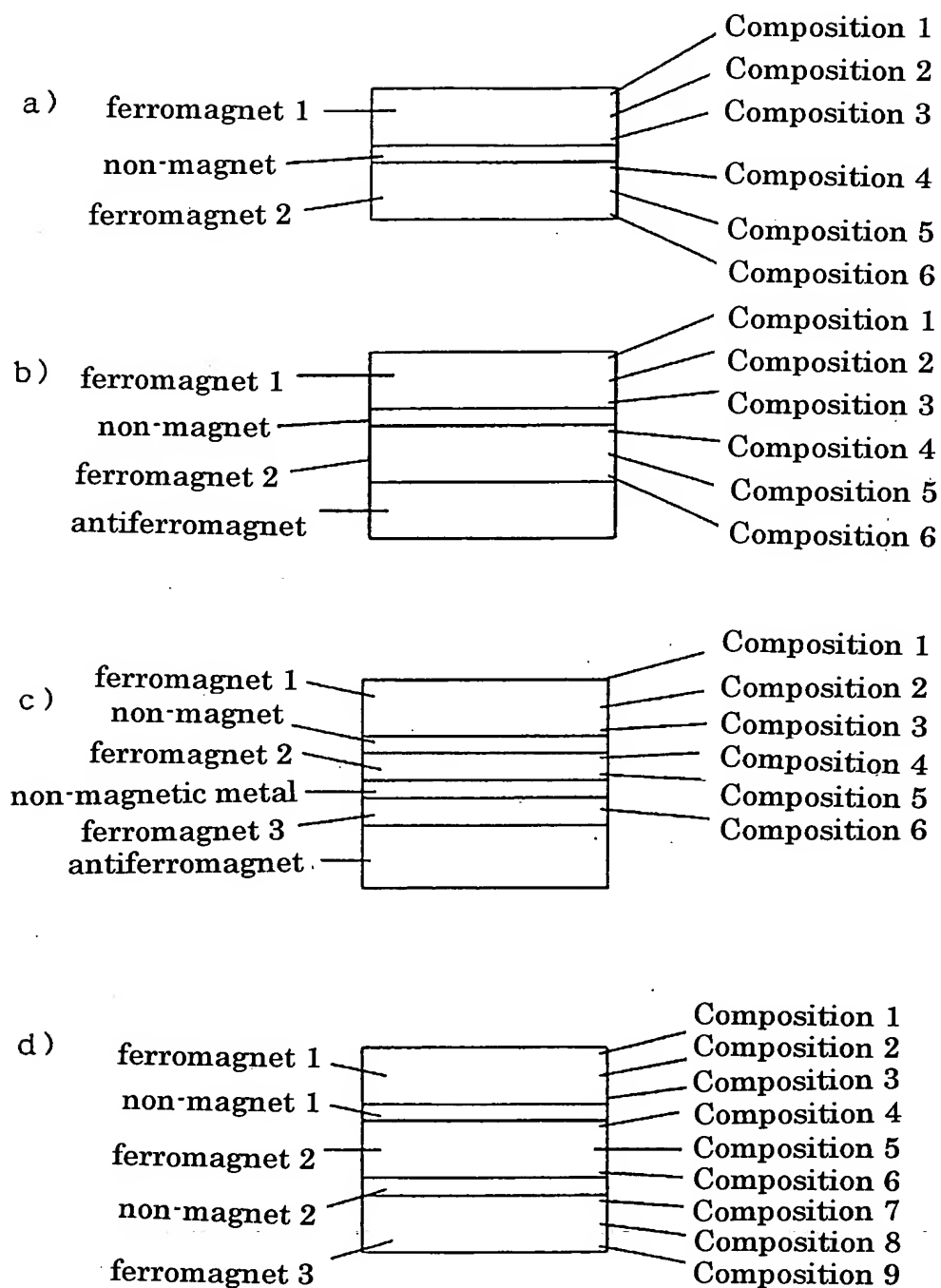


[FIG. 3]



example of structure of an magnetoresistive element

[FIG. 4]



schematic view of the magnetoresistive element of Example 2 and 3